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TEST RIG FOR HELICOPTER

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BRITAIN NEEDS AN ACCELERATOR

A DISCOVERY which is almost certain to be of profound practical importance is described in this issue (page 58). The fusion of hydrogen atoms has been accomplished without the use of high temperatures, and a convenient means of producing power from nature's most abundant fuel seems almost within our grasp. It is a development of special significance in Britain owing to the shortage of indigenous fuels, including uranium. Yet Britain lacks the tools either for making or for pursuing such a discovery.

Until now it has been generally supposed that to penetrate the electrical repulsion barrier between atomic nuclei, a battering-ram technique calling for very high particle velocities would be necessary. Such velocities in terms of kinetic theory mean extremely high temperatures, and it has been thought that to initiate a fusion reaction, temperatures of the order of ten or several hundred million deg. C. would be required. The containment of such a process and the immense associated heat losses present technical difficulties which seem almost insuperable. Recently, however, an entirely different approach, in which the structure of the atom itself is modified, has permitted fusion to be achieved on a laboratory scale at the low temperatures at which hydrogen is liquid. Thus a nuclear process which would produce no harmful by-products, and for which no fuel would need to be imported, is at last seen to offer reasonable prospect as a source of commercial power.

There is of course a snag. The essential catalyst in the new process, the so-called negative μ meson, which is produced artificially by an extremely high-powered particle accelerator, is too short lived to take part in a sufficient number of fusions to give a favourable energy balance. But there is reason to suppose that a suitable long-lived particle does in fact exist. (Such a particle does not necessarily mean the final answer to the problem; this would only be the case if the particle could be obtained with low expenditure of energy.) The fusion experiments have been carried out in California by an American team, and the long-lived particle has been postulated by a physicist in the Soviet Union.

What is it that these two countries alone possess which has enabled them to make such rapid strides towards the controlled fusion process—a process that may solve the world's fuel problem for ever? Both have particle accelerators rated in excess of 5 GeV (5×10^9 electron volts) with considerable beam intensities. Professor N. F. Mott, of the Cavendish Laboratory, has said recently that Britain may have a multi-million volt particle accelerator as part of a new academic research station. Its construction is a most urgent task, worthy of the maximum financial support. Our decision to build an accelerator of this size may mean a reconsideration of our relationship with CERN, the European Organisation for Nuclear Research, which is building a 25 GeV proton-synchroton, and to which the United Kingdom is contributing £345,000 a year. Britain's resources are small compared with those of Russia and the United States, and in the long run we may be compelled to throw in our lot with the other European countries or with the Commonwealth.

There are several conclusions to be drawn from the situation we have described. Firstly, academic research is seldom purely academic in its consequences. Secondly, it is important to recognise that a scientific idea can be passed to the engineer for technical development too soon. No doubt we should in time have discovered how to apply the hot fusion reaction, but development work on this approach may prove to have been premature. Now that the physicist has taken another step, the engineer's problem may be much simpler.

Thirdly, there is the question of policy making. Traditionally our statesmen and administrators are men with little or no technical training, and for this reason they are frequently ill-equipped to make the decisions of an industrial society. For example, in order to recognise the practical value of costly particle accelerators, and to reach a decision of immense long-term consequences, it might be necessary to grasp the significance of the American fusion experiments; a man incapable of that is scarcely in a position to weigh the comparative merits of accelerators and, say, Hollywood films as candidates for national expenditure. With this in mind we have endeavoured to make our article on cold fusion as self-explanatory as possible, so as to require no specialist knowledge beyond elementary mechanics. The impatient scientist or engineer must often feel very frustrated when explaining his needs to those who hold the purse strings. As has been said in another context: "You can get the same glassy stare by declaiming Gaelic poetry to a deaf sea-gull."

The importance of the accelerator is further underlined by the possibility that it may provide the only practical source of the catalytic particle essential to the exploitation of the fusion process. Accelerators may thus prove to be useful not only as research tools but also as indispensable items in future power installations, possibly serving several fusion reactors. Fusion may one day replace

the fission process in practical value (except for the production of radioisotopes), and it is consequently important to establish the date at which resources should be diverted from one process to the other. No time should be lost in building a particle accelerator—literally, the bigger the better. With its aid we may yet learn to use the energy latent in our oldest ally—the sea.

* * *

Plain Words

No trouble is being spared by the steel industry to impress everyone with the fact that steel prices should be higher than they are at present. The campaign is pursued with subtlety and persistance. Its latest manifestation appears in *Steel Review* No. 5 put out this month by the British Iron and Steel Federation. The argument is repeated—it has appeared in this review and elsewhere many times over the past year or two—that steel is too cheap for the industry to make adequate internal financial provision for an investment programme at the rate of £100 million a year over the next decade.

The question is much more complex than the supporters and antagonists of cheap steel will admit. It is only too easy for the steel industry to manoeuvre itself into the dangerous position where the finance argument is no more than a handy excuse for getting away from the consequences of the nation's cheap steel policy. For the industry, it has to be admitted that it is being asked to do what many of its cusomers, notably in the engineering industry, would shrink from doing. Steel makers have been repeatedly criticised for not pursuing a more virile expansionist policy since the war. Their critics say that the industry's estimates of its future market have been consistently too conservative and that it is still conditioned by the restrictive ideas which were current in the 1930's. It has to be remembered, however, that the steel industry serves, on the whole, a group of conservative industries. With the exception of motor vehicles, most of the engineering industry is as conservative in its investment policy as it claims the steel industry to be. Is it reasonable to demand that the steel industry shall carry the risk of over-expansion which should, at least in part, be borne by the steel-using industries? What industry can reasonably be expected to plan for expanding markets when those who constitute the market are reluctant to expand?

The steel industry quickly follows up this line of thought by asking its customers to expect higher steel prices as their share of the risk in a bolder expansion programme for steel makers. It thereby admits that its own attitude could be bolder, given certain conditions, but it also places the alternative clearly before the steel-using industries. Either these industries must show more faith in the future by expanding boldly and imaginatively as an insurance for the steel industry or accept steel prices high enough to cover a portion of the investment programme and a margin for a rapid depreciation of steel plant: alternatively, steel prices must go free.

BIOMECHANICS: THE APPLICATION OF ENGINEERING TO MAN

By Dr. J. M. Zarek, A.M.I.MECH.E.*

The association of engineering with the activities of man in relation to machines, bridges and buildings is familiar enough, but the application of mechanics and of engineering principles to the human body is not so well appreciated. To use a machine to its best advantage, or to repair it, the principles on which it works, and the physical properties of the material of which the components of the machine are made, must be well understood. The same also applies to the human body. To be able to repair or replace something in the human body itself that has been damaged by an accident, or disease, or supply something that nature failed to provide for man, the mechanics and engineering of the skeleton and muscles as they are used in everyday activities must be understood. To use man to his best advantage the "biomechanics," of the average man must be fully understood.

Biomechanics, in its most general sense, may be defined as that branch of science which applies the methods and techniques of engineering mechanics to the analysis of the effects of the external and internal forces acting on the human body, at rest and during movement, under normal or diseased conditions.

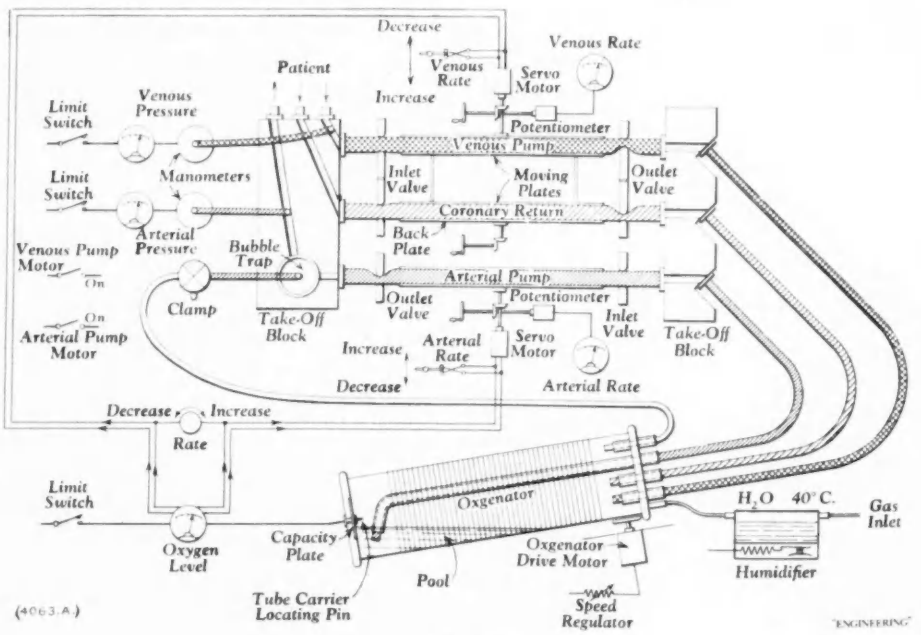
Theoretical biomechanics discusses the motion of living bodies as a specific case of mechanics; it does not formulate new principles, but makes use of the existing fundamental laws of mechanics. Its premises are therefore within the familiar field of mechanics and lead to the interpretation of observations through a process of deductive reasoning. The movement of the living body in such processes as locomotion, breathing, or blood flow may be very complex but it must be clearly recognised that if any of these functions is found to be faulty, it is for a cause to be diagnosed and it is not the assumed mechanical law that is wrong. When dealing with a living body the difficulty is not that of appreciating the relevant mechanical laws but the neglect of the effect of other laws, not of mechanical nature, which take part in the mechanical behaviour of the human body. Biomechanical studies serve as a basis for the analysis of man in industry, sport or the military field, and in the case of disease or accident may be directly applied to the innumerable processes of repair of the human body. In these processes of repair, biomechanics makes full use of conventional engineering, materials and techniques in a specific manner which can be properly described as human engineering.

* Of the Faculty of Engineering, King's College, London.

EARLY STUDIES

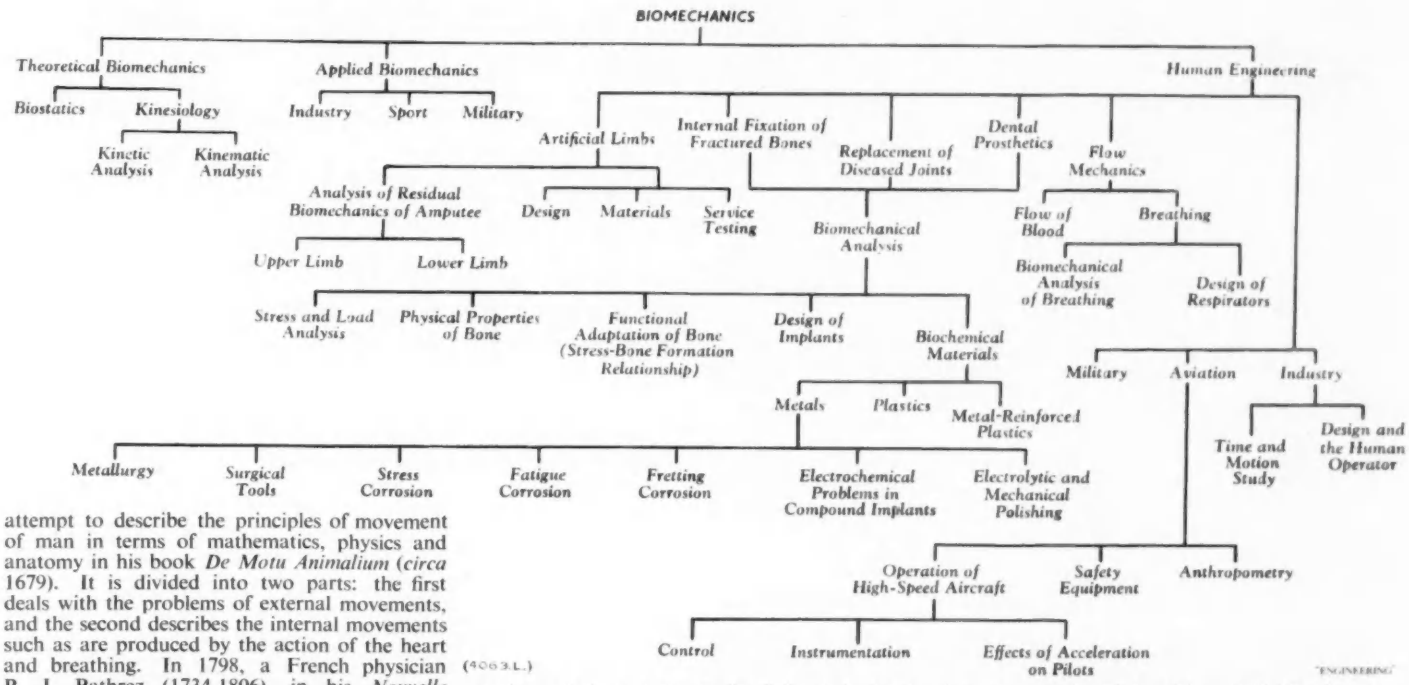
The first signs of interest in the problems of movements of man's body came from Leonardo da Vinci (1452-1519) who described his investigations in his *Notes on the Human Body*. Just over a century later, when Newtonian principles had been established, Borelli (1608-1679) made an

Fig. 2



Figs. 1 and 2 This machine makes possible direct access to the interior of the heart during cardiac surgery. The hydraulic circuit of the heart-lung machine is shown in the diagram.

Fig. 1



attempt to describe the principles of movement of man in terms of mathematics, physics and anatomy in his book *De Motu Animalium* (*circa* 1679). It is divided into two parts: the first deals with the problems of external movements, and the second describes the internal movements such as are produced by the action of the heart and breathing. In 1798, a French physician P. J. Bathrez (1734-1806), in his *Nouvelle Méchanique des Mouvements de l'Homme et des Animaux*, discussed the shortcomings of Borelli's work and put forward what he called the " true theory of movements of the human and animal body." Further work had to wait the Nineteenth Century, when the brothers Edward (1806-1871) and Wilhelm (1804-1891) Weber, physician and physicist respectively, made the first investigation of gait and attempted its mathematical analysis, outlined in their book *Mechanik der Menschlichen Gehwerkzeuge* (1836). The classical work of Christian Braune and Otto Fischer, *Der Gang des Menschen* (1895) has been used as the main guide for laying down the principles for the design of artificial legs. This present century is noted by the efforts of Bernshtein, Popova and Mogilyanskaya in Russia and part of this work is described in Bernshtein's book (in Russian) (1926; 1935), the title of which might be translated as " General Biomechanics." The work of the teams of engineers and anatomists now at the Universities of California and New York is becoming so well known that it can only be mentioned here in passing, for it merits its own story.

From these brief historical remarks it can be seen that investigators in France, Germany, England, Russia and the United States have been or are studying the performance of the human body, but there has been a very great variety of objectives in view. A study of the accompanying "tree" shows that the number of engineering problems related to the human body is very great; they may also be of a very complex nature, for in most cases they refer to the behaviour of the living tissue.

From an engineering standpoint, biomechanics extends into many spheres of medical science, but the recent considerable clinical advancements in the treatment of heart and lung deficiencies, and in orthopaedic surgery, are in need of more detailed biomechanical knowledge, making full use of the contribution of engineering techniques.

Fig. 3 Light-metal artificial limb for an above-knee amputation, constructed from seamless pressings, and with double-swivel pelvic-band assembly; the cut-away sections show the wheel-control knee mechanism and cushion-joint ankle.

Fig. 4 Hydraulic knee unit under development, using the dash-pot principle to overcome " knee shoot " for above-knee artificial limbs.

HEART AND LUNG MACHINE

A recently developed British machine, which takes over the normal function of the heart and lungs, now makes possible direct access to the interior of a diseased heart which can be made to stop beating for the duration of an operation, while the veins and arteries leading to and from the heart are clamped off to exclude the circulation from the heart, the body's demand being met by the machine. This example is an excellent illustration of the application of biomechanical and engineering knowledge. To have been able to conceive the working idea of this machine, the biomechanics as well as the,

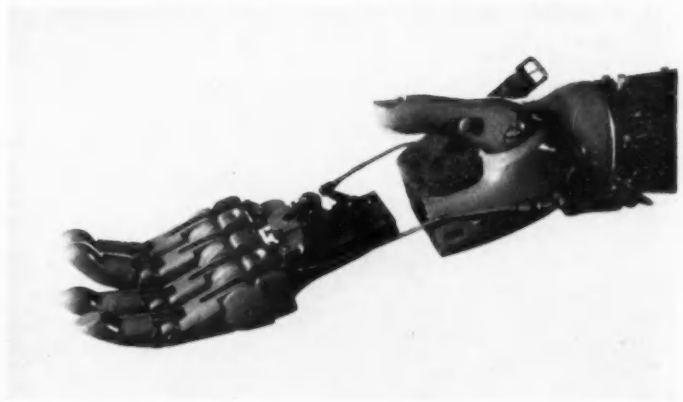


Fig. 5 (right) An example of a mechanical hand. The passive grips made available, because of the loss of the sense of touch, allow the wearer to attain confidence and reliance in the device.

Letters to the Editor

AN ENGINEER'S CARD INDEX

SIR, It is surprising how few engineers have a card index for technical articles in their field of study. The common excuse of lack of time is the very reason for requiring to have an up-to-date index at hand.

Because of the overpowering output of technical literature to-day, librarians cannot be expected to carry out detailed indexing unless the field concerned is very narrow and the librarian has been specially trained in it. The consequence has been that articles have been forgotten, and experiments or errors duplicated, thereby causing a great waste of public and private money alike.

A card index for an engineer must be simple, efficient and expandable. Simple to place and replace cards. Efficient in recording all necessary data. Expandable, to cater for a growing "library." Unless the procedure is kept simple the inertia of inaction will prove too great. Therefore, it is advisable, in the first place, to group the cards under a limited number of subject headings.

Choosing the type of card is a personal matter and depends upon the amount of information to be recorded. One advantage of a personal index, of course, is that personal comments and summaries can be recorded as well as more essential details. Although different colours can be used to designate different sources, such as libraries, or particular magazines, it seems advisable to use one colour only, because, at critical moments, cards tend to run out and become unobtainable for a time.

The main details to be recorded on each card are the title, author, source and date of publication. The cards then need to be placed in a cabinet in such a way as to make subsequent searching as easy as possible. As already suggested, the first grouping should be according to subject, and these subjects can be designated by a letter, which can be printed in a specific position at the top of the card. With eight groups, the card would have eight divisions across the top with a letter in each. As an example of grouping, the following has been used for the general topic of physical oceanography:

W . . waves	L . . littoral drift
F . . forecasting of waves	M . . models
	WR . . wave recording
R . . refraction	S . . sediment movement
D . . diffraction	

These letters should be printed large enough for any suffixes which may be added to be of a reasonable size. Suffixes are included when any one group becomes too large for efficient working and the cards are sub-divided. Groups will expand, of course, at different rates. Examples of sub-dividing some of the above-mentioned groups are as follows:

W wave (theory)	S . . sediment movement (theory)
W_F . . wave forces	
W_S . . wave surging	S_M . . measurement of
	S_E . . in estuaries

As regards the reference details on each card, the most important avenues through which information will be sought later are the author and year of publication. These, therefore, must be prominent. Both items should be printed boldly in the same position on successive cards so that, when they are being sought, the eye does not have to roam all over each card.

At the front of each group a card should be placed having the letter heading protruding. As each letter has an appropriate position across the top of the card none will be hidden behind the other, even at the inauguration of the index. The cards should then be placed behind this header card in the order of the year of publication, with the latest publications at the front. This procedure has several advantages:

(*a*) The cards covering current journals are easily placed, directly behind the header card;

(*b*) Once the author and year are known only a few cards need perusal before the appropriate one is found;

(*c*) A rough classification of the importance of the references is made by placing them in the order of their appearance;

(*d*) To replace a card it is necessary only to flick over the cards until the year appears, which gives a wide margin of choice.

Yours faithfully,
R. SILVESTER,
Senior Lecturer in Civil Engineering (Hydraulics).

University of Western Australia,
Nedlands,
Western Australia.
January 1, 1957.

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THE CENTURY OF WHAT?

SIR, Your interesting Leader this week, referring to a comment of Dr. Ludwig Mond on the future of gas power, prompted my mind to recall some memories of the gas engine age. You apparently refer to Dr. Mond's remarks when opening the discussion on the classic paper by H. A. Humphrey at the Mechanicals in 1900.

At that period there was a strong school of thought that visualised the gas engine and gas producer as the future source of motive power. The discussion on Humphrey's paper gave some evidence of this belief. Mond had created his producer by means of which he visualised the power of the future and also a "Smokeless England." Hamilton designed and built his famous "Premier" gas engines, and so the road seemed clear. The dream of the power engineer at that time was the gas turbine, but the problems to be solved had to wait for further research. In the meantime, Parsons made progress with his steam turbine, and so filled the gap of increasing power demands.

There were many enthusiastic minds at work during this early period. Mond was using a producer employing bituminous coal and he had also recovered sulphate of ammonia. Dowson was building a producer to use coke. In those days, an engine unit of 1,000 b.h.p. was a large unit, and to have visualised a power unit of only 150,000 b.h.p. would have been fantastic. With such progress behind us, what do we visualise for the end of the present century?

Yours truly,
JOHN D. TROUP,
Managing Director.

John D. Troup, Limited,
90 High Holborn,
London, W.C.1.
January 1, 1957.

DISTINCTIONS FOR NUCLEAR ENGINEERS

The New Year Honours List

The most outstanding of the recently-announced New Year Honours are those which have been conferred by Her Majesty in connection with the development of atomic energy resources in this country.

Sir John Cockcroft, K.C.B., C.B.E., F.R.S., who is an Honorary Member of the Institution of Mechanical Engineers and a Member of the Institution of Electrical Engineers, has received the signal honour of appointment to the Order of Merit. With his distinguished achievements in the nuclear power field readers of ENGINEERING have long been familiar. He became Director of the Atomic Energy Research Establishment at the Ministry of Supply as far back as 1946, after having been Director of the Atomic Energy Division, National Research Council of Canada, during the two previous years. The distinction of Knight Commander of the Order of the British Empire has been conferred on Sir Christopher Hinton, F.R.S., M.I.C.E., M.I. Mech.E., member of the board of the United Kingdom Atomic Energy Authority, and that of knight bachelor upon Mr. William L. Owen, C.B.E., director of engineering to the Authority's industrial group.

Among other engineers upon whom the honour of knight bachelor has been conferred may be mentioned the names of Dr. David S. Anderson, F.R.S.E., M.I.Mech.E., Director, Royal College of Science and Technology, Glasgow; Mr. John N. Dean, B.Sc., chairman, Telegraph Construction and Maintenance Company, Limited; Mr. Josiah Eccles, C.B.E., M.I.C.E., M.I.E.E., deputy chairman (operations), Central Electricity Authority; Mr. George R. Edwards, C.B.E., F.R.Ae.S., managing director, aircraft division, Vickers-Armstrongs Limited; and Mr. John Landale Train, C.B.E., M.I.C.E., a member of the British Transport Commission. Knighthood has also been bestowed upon Mr. Charles P. Snow, C.B.E., who has been a commissioner and scientific adviser to the Civil Service Commission for some years.

Another honour which is likely to give general pleasure is that conferred on Colonel Sir Stanley Angwin, K.B.E., chairman of the Commonwealth Telecommunications Board, and, formerly, chairman of Cable and Wireless Limited, who has been created a Knight Commander of the Order of St. Michael and St. George. Mr. Reginald J. Halsey, B.Sc.(Eng.), M.I.E.E., assistant engineer-in-chief, General Post Office, and Mr. John A. Fargher, railways commissioner, South Australian Railways, have been made Companions of the same order. Companionships of the Order of the Bath have been bestowed on Mr. John F. A. Baker, M.I.C.E., chief engineer, Highways Engineering Staff, Ministry of Transport and Civil Engineering; Mr. Bertie K. Blount, F.R.I.C., deputy secretary, Department of Scientific and Industrial Research; and Dr. R. H. Purcell, B.Sc., F.R.I.C., chief scientific adviser at the Home Office.

Those upon whom the Order of the British Empire has been conferred include Sir Archibald F. Forbes, chairman of the Iron and Steel Board, who becomes a Knight Grand Cross; and Mr. Donald M. Campbell, the holder of the world water speed record, who has been made a Commander in recognition of his services in the development of speed boats. Other persons upon whom a C.B.E. has been bestowed include Dr. Charles M. Cawley, O.B.E., F.R.I.C., deputy chief scientific officer, Department of Scientific and Industrial Research; Mr. E. Leslie Champness, M.B.E., managing director, Palmers (Hebburn) Company Limited, Hebburn-on-Tyne; Mr. A. A. Fulton, general manager, North of Scotland Hydro-Electric Board; Mr. Arnold T. Green, director of research, British Ceramic Research Association; Mr. Olliver W. Humphreys, B.Sc., M.I.E.E., director, Research Laboratories, General Electric Company Limited; Mr. Peter Lloyd, deputy director, research and development, National Gas Turbine Establishment, Farnborough; Mr. Robin McAlpine, director, Sir Robert McAlpine and Sons Limited; Mr. E. John Powell, chairman, Road Research Board; Mr. Eric J. Sturgess, A.M.I.Mech.E., chief engineer, Shell Petroleum Company, Limited; and Lieut.-Commander John W. Thorneycroft, R.N.(retd.), managing director, John I. Thornycroft and Company, Limited, Southampton.

Officerships of the Order of the British Empire have been conferred on Mr. William Barr, technical director, Colvilles, Limited, Glasgow; Mr. Emrys G. James, valve group, General Electric Company, Limited; Mr. Hans Kronberger, chief physicist, research and development branch, U.K. Atomic Energy Authority; Mr. J. S. Williams, Director, Coal Utilisation Council; and Mr. Harry K. Worship, general manager, Laurence, Scott and Electromotors Limited, Norwich.

Weekly Survey

Cover Picture: *The helicopter test gantry is used for testing the functioning and endurance of the helicopter transmission, the rotor hubs and the power-plant units. Lift spoilers, such as drogues, are fitted to the rotor blades in order that the full power can be transmitted from the engines to the rotors without danger of the aircraft rising into the air; at the same time hanging condition ensures that the rotor thrust bearings are loaded during test. The gantry structure is produced from standard Bailey bridge components.*

★ ★ ★

America Steps in

President Eisenhower told Congress last week-end that " the Middle East has abruptly reached a new and critical stage in its long and important history." Clearly, his Government expected the Soviet Union to move forward—perhaps into Syria—taking advantage of the chaotic situation likely to prevail until ships sail through Suez once again and oil begins to flow normally to the West. The declaration of American interest in the area—the Eisenhower Doctrine—makes plain that any Soviet attack will trigger off an American reply; there is no possibility of " small " local wars without the strong probability of an " atomic " world war.

To a good many, this would have been quite enough. But the Eisenhower administration believes that Britain and France have been stripped of their political acceptability in the Arab world, and that they cannot afford to finance the development of the area on a scale adequate to offset political discontent. The proposal, therefore, is that the United States should assist any nation or group of nations in the area " in the development of economic strength dedicated to the maintenance of national independence " and with " programmes of military assistance and co-operation " if asked for. The President said that such assistance and co-operation would include United States troops as well as United States dollars.

Doubts have been expressed concerning the acceptance of such a dynamic policy by a Democratic Congress but, on the whole, it is likely to go through. It would be easy for the British and particularly those who export to the Middle East, to be cynical and to read in President Eisenhower's speech a proprietary claim to yet another of the world's rapidly developing markets. On the other hand, if the Russian threat exists it could take a variety of shapes difficult to identify with aggression. There is a strong case for economic aid on the scale proposed—about 400 million dols. during the next two years— to undertake schemes that will raise a deplorably low standard of living.

The British exporter will ask if this will mean that most of the plums will go to his American competitors. As is general in countries receiving American economic aid many, but not all, the plums go to United States firms. More, in fact, come to Britain than would have been the case had no aid been granted. There is little doubt that competition to established British exporters would increase, in agricultural machinery, irrigation plant, constructional engineering, etc., but these are products which British firms can supply at highly competitive prices. On the whole, therefore, America's entry into the Middle East is to be welcomed—first as the guardian of Europe's oil and second as a source of capital for the economic development of the area.

★ ★ ★

Steel in the 1960's

The steel industry is beginning to think in terms of a capacity of 28 million tons by 1962. If this were to be met entirely from home production, pig-iron output would have to be stepped up to 20 million tons. Towards these target figures, development schemes have already been submitted for central approval including 7 new blast furnaces, 5 new melting shops, 5 new plate mills, and major developments in heavy sections, re-rolled products, billets, tinplate, sheet and special steels. These figures are given in the British Iron and Steel Federation's *Steel Review* for January.

Over the years 1946 to 1956, the steel industry spent about £165 million on replacement and £385 million on expansion—a total of £550 million. At present day prices this amounts to £710 million or an annual average outlay of £64·5 million. It seems likely that £80 million was spent in 1956 (much less than estimated owing to construction delays). This means that in 1957 the industry will spend well over £100 million since an effort will be made to catch up with the delays encountered in 1956. In 1958 the industry expects to spend £70 million. Between 1958 and 1962 the industry may have to spend about £100 million a year on fixed assets. Such a rate of replacement and investment will involve a heavy call on financial resources.

Over the years 1957 to 1962 the industry faces a replacement programme of about £175 million which should be fully covered, with a reasonable margin, by steel prices. This leaves £515 million to find for expansion. In the last decade normal internal resources, which means profits ploughed back, provided about half the necessary funds and the other half came from external borrowing and exceptional internal resources. The industry is not optimistic about being able to raise large quantities of equity capital in the open market although it sees some prospects for loan capital. Since normal internal resources can be expected to increase only in proportion to output and prices there is a large financial gap in prospect, estimated to be about £20 million a year. In the words of the *Steel Review*, " if there is a clash between large prices and adequate expansion, which does the consumer choose?" The argument is given an airing in Plain Words this week (page 34).

★ ★ ★

An Important Merger

The merger of Broom and Wade, Limited, of High Wycombe, Buckinghamshire, and Holman Brothers, Cambourne, Cornwall, is a major step forward in the integration of the compressor industry. The new unit, which also includes the Climax Rock Drill and Engineering Works, Limited (controlled by Holman), should have a competitive strength much greater than had the individual companies, particularly in overseas markets. The Group will have the help of the Holman factories in the Union of South Africa and Australia—both major markets for pneumatic mining equipment and compressors—and should be in a position to increase total exports which already account for 50 per cent. of their joint output. They will be one of the largest suppliers in the world of rockdrills, air compressors, pneumatic tools and a comprehensive range of ancillary machinery and equipment.

The terms of the merger have yet to be announced. Broom and Wade are a public company, whose profits for the last financial year to September 30 amounted to £623,700 before tax. Holman are a private company and a family business, but a substantially larger enterprise. Their subsidiary Climax Rock Drill is a public company with excellent cash reserves and dividend cover. It is likely therefore that the new group will be strong financially as well as commercially. The announcement of the merger stated that both companies are working to full capacity with large order books, and there is every prospect of a continuing advance. The performance and prospects of the Joy Manufacturing Company, Pittsburgh—discussed in another note on page 40—suggest that the demand for mining equipment for coal and metalliferous ores is rising fast and has a long way to go before reaching its peak. As much of this lies overseas there is a great deal to be said for two strong units, with established world reputations, pooling their resources to increase their share of world markets.

The companies emphasies that the degree of overlap in their products is small, and that where these are similar they are sold in different markets. On the whole, therefore, the merger would appear to be an excellent proposition from every point of view.

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Machine Tool Orders Easier

Published figures now show that there was a noticeable easing in the order-book position for the machine-tool industry in the third quarter of 1956. Indications are that the downward trend continued in the closing months of the year. At the end of the third quarter, the order book stood at £102·90 million compared with £104·99 million at the end of the previous quarter. By the end of September orders in hand represented about 14 months production, which means that the industry had lost momentum to the extent of about one month's production compared with the early part of the year.

The situation is particularly uncertain in the home market. New orders in the export market were maintained at £1·88 million during September but orders for the home market for that month were down to £4·63 million, over £1 million less than the same month of 1955.

The last quarter of the year is usually a peak period for the industry and if the September rate of output has been maintained through to December the total output for 1956 will have been about 10 per cent. above that for 1955. Much now clearly depends on the course of the credit cycle in the first half of 1957. The machine-tool industry is itself a useful indication of the trend of investment in plant and equipment. There have been signs already that orders for small standard machines have been quickly cancelled, and the impact of the Suez crisis on industrial production (operating both through a fuel shortage and a lack of transport) may be sufficient to cause further cancellations of orders. Indications as to whether this is going to happen will be anxiously awaited both by the industry and by those who fashion the Government's economic policy. A sudden drop in machine-tool orders would indicate a change in business sentiment. As discussed in last week's leader, so far this winter the rate of capital investment has shown signs of slowing down; most people, however, can live with a slower rate of increase without becoming nervous. If the next set of published figures on machine tools shows a significant worsening in the order position an important pointer will have been given to the need to reverse economic policy even before the next Budget.

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" Against the Public Interest "

The Monopolies Commission has at last discovered the perfect monopoly: one which fits the text-book definition in almost every respect. They found that the prices charged by the British Oxygen Company, Limited, for oxygen and dissolved acetylene are " unjustifiably high " and " operate against the public interest." The company have eliminated competition gradually by buying out competitors and now account for 98½ per cent. of these gases sold in Britain. Until 1955 the company appeared to have four competitors but in fact three of these were owned by B.O.C. and that one of them was used as a " fighting company " to undercut the prices of the only remaining competitor in certain market ing areas. Much of the oxygen supplied is sol- under contracts that make exclusive dealings a condition of supply. No price list is published and customers are charged at different rates.

The main weight of the commission's criticism is concentrated on prices and profits. In 1952-54 B.O.C. earned on capital employed a profit of 23 to 24 per cent. which was one-third to one-half higher than the weighted average for manufacturing industry. The Commission consider that B.O.C.'s profits "have been unjustifiably high for an almost complete monopoly facing a limited financial risk." They say that too little is probably spent on research and development. Although the company has set up its own research department since the war and are currently spending 2½ per cent. of turnover under these headings, most of the significant improvements and developments have come from outside this country. Another criticism is that, in the past, B.O.C. deliberately sought to control the provision of oxygen plant to others so as to maintain their monopoly.

In a reply to the Commission's report B.O.C. point out that the report comments favourably on the general efficiency of the company in production, supply and technical service, that no evidence was found that costs were high; that the Commission are divided in their comments on prices and profits (two members disagree with the majority's findings in this respect). Now the matter is passed over to the Board of Trade. Two of the members have suggested that "the desirability of public ownership and management, with a guaranteed return on capital, should be seriously considered." All agree that the monopoly position of B.O.C. operates against the national interest. But some measure of price supervision is all the commission suggest. Nothing apparently is to be done to break up the monopoly into competing units as would probably be done in the United States. There would seem to be few other useful solutions.

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Rationing of Petroleum Products

The various schemes for the rationing of petroleum products have hardly yet been in operation for sufficient time to permit a considered judgment as to their success. Bearing in mind the number of people affected, however, the schemes operated by the Ministry of Fuel and Power for the rationing of fuel oil to industry and of petrol to private motorists have given rise to surprisingly little complaint—though rumours persist that a cut in the basic ration is imminent. On the other hand, the rationing of petrol and Diesel oil by the Ministry of Transport to commercial users has given rise to a great deal of controversy and has resulted in the recalling of the Minister of Transport from holiday and discussions at Cabinet level.

The cut of 10 per cent. in supplies of fuel oil to industry appears to have been well absorbed and to have created very little dislocation. It was originally hoped that by drawing on stocks held in the country it would be possible to maintain the 90 per cent. allocation until the summer but there are now fears that, because of the inability to expand supplies from Texas, a further cut may become necessary.

It is very difficult at present to assess the position regarding supplies to the road haulage industry. The road hauliers have complained of discrimination in that total supplies to commercial road transport operators will be limited to 75 per cent. of normal consumption. From the national point of view, however, the Government are undoubtedly right in insisting that as much traffic as possible should be diverted from road to rail. The Road Haulage Association have complained, however, that A and B licence holders, who depend on the carriage of goods for their livelihood, have not received more than about 25 to 30 per cent. of their normal consumption by way of basic ration and have said that they will continue to press for petrol for their members to avoid heavy financial loss, bankruptcy and unemployment. It is impossible to escape the conclusion that there has been some unnecessary delay in the issue of supplementary rations and it would appear that many individual haulage contractors, in the absence of information as to what their total allocation will be, have used up the basic ration too quickly.

The Minister of Transport has refused to admit the existence of a crisis and has stated that it was always recognised that there would be three phases in the scheme: the first being the issue of the basic ration, the second the first round of supplementaries and the third the individual problems which will require special treatment.

Up to the present there appears to have been very little diversion of traffic to the railways, and it is possible that this is in fact one of the main reasons for slowness in the issue of supplementary rations since time is inevitably required to determine what traffic can in fact be diverted. Assistance to the road haulage industry is, however, not solely a matter of alleviating individual hardship but of making sure that the industry will not have been crippled by the time that additional oil supplies again become available.

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An American Company Report

The 1956 annual report of the Joy Manufacturing Company, Pittsburgh, Pa., U.S.A., is one of the most informative and most attractively presented we have been privileged to read. Joy make mining machinery for coal, iron ore, non-ferrous ores and other minerals as well as oil-well, construction and industrial equipment. They are probably best known in this country for their cutter-loaders and other coal-mining machinery, supplied from their establishments in Dronfield and Greenock. They employ about 6,000, including nearly 500 engineers, scientists and associated technical personnel—or 8 per cent. of the total pay roll is employed on research and development. Expenditure on "research and product engineering" in 1956 amounted to 3½ per cent. of total sales. Among the new products launched in 1956 were the "microdyne" dust collector—"more successful than many units 20 times its size"—a range of special-purpose high-pressure compressors for guided missile application and axial-flow compressors for use in "nuclear-engine" laboratories.

The tremendous prosperity of the United States mining interests, particularly of coal, metal ores, oil and uranium, is fully reflected in the company's results. Earnings for the year rose by 92 per cent. to 10·9 million dols. and sales by 48 per cent. to 121 million dols. A comment of great interest, particularly in view of so many reports to the contrary in recent years, is that "growth, experienced in all phases of the company's operations, was led by coal-mining equipment, demand for which coincided with the resurgence of coal as an energy fuel."

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Longest Career in Radio

Mr. Raymond Dorrington Bangay, foreign manager of Marconi's Wireless Telegraph Company, Limited, retired at the end of December after serving with the company for more than 54 years. He joined in 1902 when it was showing more promise than profit—it was not until 1910 that it showed anything but a financial loss—and has since seen a most immense evolution in all aspects of this field of engineering. At the time of his entry into radio engineering all transmitters were large induction coils with sparks impressive to eye and ear; the different distances of day and night communication were attributed to the effect of the sun on the transmitter; a new system of transmission—the "syntonic system"—in which tuned circuits were introduced was being mooted; and the Postmaster-General was doing his best to prevent wireless from developing into any sort of menace to his telegraph system.

During the last 54 years many innovations—both in wireless techniques and in Postmasters-General—have been witnessed by Mr. Bangay. He was made chief of designs in 1921 during the critical period of the evolution of radio practice from spark to valve technique and, although no longer a member of the design staff, has seen—during the last decade—the beginning of the new evolution from valve to transistor techniques. Mr. Bangay left the design staff in 1925 when he became technical representative abroad. The appointment to foreign manager followed in 1935.

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Dame Caroline Haslett

The circumstances of the 1914-18 war brought forcibly home, both to the Government and to the nation, the part that women could play in the production of munitions. When hostilities ended, and re-organisation became the watchword, it became equally clear that changes must be made in our arrangements for the supply of electric power; and that these must ensure greater attention being paid to the development of the domestic load, a field in which women could again be of great assistance. It has often been proved that the occasion brings the man; this was again shown to be true at that time, although in this case it was a woman that played a leading role in the developments that have taken place in both these fields. For it was Caroline Haslett, whose death we regret to record occurred on Friday, January 4, at Bungay, Suffolk, at the age of 61, who was largely responsible for removing the obstacles and prejudices which prevented women from qualifying as professional engineers and who, by the exercise of her outstanding abilities of organisation and persuasion, did so much to show how electricity could be used to lighten the daily round of domestic tasks.

A formal statement of the events of Caroline Haslett's life does little to illustrate the personality which was the main factor in her success, although it was evident to all who knew her. She was born at Worth, Sussex, on August 17, 1895, and began her connection with engineering by obtaining a clerical position with Cochran and Company, subsequently, at her own request, being transferred to a post in the works. It was doubtless the experience thus gained which led to her appointment as secretary of the newly-founded Women's Engineering Society in 1919, and the fact of her editing an *Electrical Handbook for Women and Household Electricity* resulted in the foundation by her five years later of the Electrical Association for Women. This body, which now has over 90 branches and some 10,000 members, subsequently became her main life's work and will be her chief monument. Its importance was early recognised by the Central Electricity Board and other branches of the industry; and the energy and wholeheartedness with which she carried out the propaganda which was its principal object was reflected in the part she was called upon to play in other spheres, the scope of which was continually widening.

To mention only a few of these activities, in 1930 she was the only woman delegate at the World Power Conference in Berlin. She was also a member of the Central Committee on Women's Training and Employment, of the Woman's Consultative Committee and Advisory Council of the Appointments Department of the Ministry of Labour and of the Correspondence Commmittee on Women's Work of the International Labour Office.

Her work in the electrical field was recognised by her election in 1932 as a Companion of the Institution of Electrical Engineers, the first woman to be so honoured. She had also been a vice-president of the British Electrical Development Association and a part-time member of the British Electricity Authority. For these and other activities she was appointed a Commander of the Order of the British Empire in 1931 and promoted D.B.E. in 1947.

The Engineering Outlook—2

In last week's issue, the first article in this series gave a picture of the possible trends during 1957 of business as a whole and particularly as regards raw materials such as steel, the non-ferrous metals and plastics. This article examines in more detail the sections of industry named below.

AGRICULTURAL MACHINERY
LOCOMOTIVES AND ROLLING STOCK
MACHINE TOOLS
TEXTILE MACHINERY
COAL AND ELECTRICITY

AGRICULTURAL MACHINERY

The difficulties predicted for manufacturers of agricultural machinery in 1956 have certainly been encountered during the past year. The credit squeeze continued to affect both output and sales in the home market, and the downward trend was sharply reinforced by further hire purchase restrictions imposed by the Chancellor in February, 1956. Figures available for the first half of that year show that total production of agricultural machinery was running at a level 12 per cent. below the comparable period of 1955, and there was no perceptible recovery during the closing months.

The brunt of the decline has been due to falling home market sales. In 1955, sales of agricultural machinery in the United Kingdom averaged £4·63 million per month. The monthly average for the first six months of 1956 was over £300,000 below this figure. Exports, which account for about 50 per cent. of output by value, have also failed to maintain the previous rate of increase. To the economic competition of German manufacturers—particularly in European markets—must be added the restrictions on trade imposed by the political situation in the Middle East. Australia and New Zealand are two of the most valuable markets for agricultural machinery, despite licensing restrictions, but deliveries are being severely affected by the closure of the Suez Canal. The full effects of the Suez crisis are not revealed in the trade figures shown in Table I, which is based on the annual rate for the first nine months of the year, but even these figures show a marked check to overseas sales. During the period January to September, 1956, exports of British agricultural machinery other than tractors totalled £14·3 million, an increase of only 1 per cent. over the comparable period of 1955, when exports were 10 per cent. up on 1954. In the case of tractors, the setback is much more marked: during the first nine months of 1956 exports were 12 per cent. below the corresponding figures for 1955, and were also below the 1954 levels.

The reasons for the decline in sales at home are not hard to find. They are by no means entirely due to the economic restrictions imposed during the last two years. It has been suggested for some time that the spurt of agricultural investment after the war is tailing off. British farmers, for instance, now own more than 400,000 tractors, and farm mechanisation, under the influence of a declining labour force and generous subsidies in previous years, has reached a very high level in this country. While there is potentially a large replacement market, this has definitely been cramped by hire purchase and other restrictions. Farmers are tending to make machines last longer, and are also buying more equipment in the secondhand market where restrictions are not so rigid.

Despite the high degree of mechanisation, there are many people who believe that there is room for still further capitalisation in British farming. Mr. A. W. Tuke, president of Barclays Bank, Limited, put forward their view when he addressed a Farmers' Club meeting in May, 1956, and said that an additional £400 million of long-term capital investment was needed before British agriculture could reach a really satisfactory standard of efficiency. This statement, however, holds cold comfort for agricultural machinery makers at the present time. A large potential demand may exist, but without generous credit facilities it is unlikely to materialise to any considerable extent, particularly since farming profits have been declining in recent years.

Total production of agricultural machinery in the United Kingdom during the last four years.

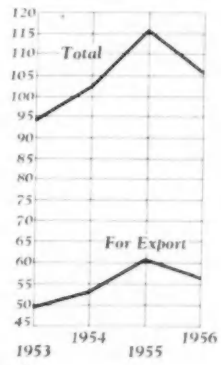


TABLE I.—UNITED KINGDOM: EXPORTS OF AGRICULTURAL TRACTORS AND MACHINERY

	Quantity (Numbers)			Value (£1,000)		
	1954	1955	1956(*a*)	1954	1955	1956(*a*)
Agricultural tractors:						
Under 10 belt h.p.	10,413	9,754	6,480	1,299	1,097	796
10 to 25 belt h.p.	42,912	26,870	20,044	15,679	9,968	7,420
25 to 36 belt h.p.	15,903	24,720	29,920	6,758	10,974	13,656
36 belt h.p. and over	37,662	43,299	38,480	19,166	21,898	19,704
Agricultural machinery:	Cwt.	Cwt.	Cwt.			
Mechanical ploughs	166,054	176,358	139,928	1,692	1,926	1,640
Other machinery for soil preparation and cultivation	277,208	278,341	265,028	3,205	3,414	3,464
Hay and grass mowers (inc. mowing attachments to tractors) other than rotary blade types	51,639	52,135	74,968	890	919	1,256
Combine harvester—threshers	147,428	143,918	140,632	2,848	2,696	2,832
Other harvesting, threshing and sorting machinery	181,901	198,336	230,024	2,711	3,121	3,724
Dairy machinery	28,235	36,405	42,092	1,382	2,009	2,556
Lawn mowers	140,741	139,723	132,068	1,827	2,034	1,856
Sheep shearers and dipping machines	3,632	4,259	3,444	246	296	236
Other descriptions	84,229	85,559	82,696	1,411	1,349	1,524
Total: Agricultural tractors (numbers)	106,890	104,643	94,924	42,902	43,937	41,576
Agricultural machinery (cwt.)	1,081,067	1,115,034	1,110,880	16,212	17,764	19,088
Grand total	—	—	—	59,114	61,701	60,664

(*a*) Nine months' annual rate.

TABLE II.—*United Kingdom: Exports of Agricultural Machinery, other than Tractors, by Country of Destination*

	Value (£1,000)		
	1954	1955	1956 (*a*)
Australia	2,984	2,992	2,800
New Zealand	1,164	1,022	1,292
Union of South Africa	862	1,068	912
Other Commonwealth countries	2,279	2,433	2,396
Irish Republic	1,989	1,984	1,712
Finland	474	935	1,012
France	517	516	1,176
Western Germany	n.i.	n.i.	659
Netherlands	376	468	636
Other West European countries (*b*)	1,306	1,269	1,448
United States of America	532	592	720
Other foreign countries (*c*)	3,729	4,485	4,325
	16,212	17,764	19,088

(*a*) Nine months' annual rate.
n.i. Not indicated separately.
(*b*) Excluding Spain, Portugal, Switzerland, and Austria.
(*c*) Including Spain, Portugal, Switzerland, and Austria.

TEMPORARY SETBACK CONTINUES

While agricultural machinery manufacturers expected some setback in 1956, it was at one time thought that the economic restrictions—claimed in any case to be only "temporary" at their outset—would be lifted in time to make 1957 another prosperous year. Their expectations took no account of the Suez crisis, which has inevitably led to a severe drain on Britain's gold and dollar reserves owing to the need to obtain oil and other essential imports from the western hemisphere. It now appears very unlikely that there will be any relaxation in the immediate future of the credit squeeze at home, and it is therefore difficult to foresee any improvement in conditions for 1957. On the home market at any rate most sectors of the engineering industry must expect to encounter difficulties, and the agricultural machinery sector will certainly have its share.

Thus it becomes even more imperative to sell more abroad. The agricultural machinery industry has one of the highest export ratios of any British industry, and must be given credit for its efforts over the last few years. There is, however, little room for complacency, particularly in view of increasing German competition. If total exports are not to suffer, it is to the European and South American markets that British manufacturers must turn to make good any decline in exports to destinations beyond Suez. Yet it is in these profitable markets that German competition is most strongly felt. The Agricultural Engineers' Association have frequently drawn attention to the growth of German competition and have pointed out that in the first half of 1956, United Kingdom exports of machinery to Eire were 45 per cent. lower than the £1·1 million recorded in the period January-June, 1955, while German exports increased almost correspondingly to this valuable market only a short distance from factories in England.

South America appears to be a profitable market which has been neglected during the last few years. Detailed figures of exports are available only for Chile and Uruguay, but deliveries of agricultural machinery and tractors to those countries fell by nearly 80 per cent. between 1954 and 1956. Yet in August, 1956, Dr. Mendez Delphino, of the Argentine Government, told the Agricultural Engineers' Association that "British tractors and agricultural machinery, if exported to Argentina, would compare favourably with prices at present prevailing there."

STRATEGIC EMBARGOES

British exporters of certain types of machinery have been hampered for some time by strategic embargoes. While perhaps politically desirable, these restrictions have without doubt affected the agricultural machinery industry's potential sales abroad. China has been the example most in the news, particularly in view of the announcement last November that the Chinese Govern-

ment intend to order "western-style" tractors for their agricultural mechanisation programme. This announcement follows a statement earlier in the year by the President of the Bank of China, Mr. Man Han-Chen, at the Leipzig Fair, that China intends to order 1,400,000 tractors from overseas, with a consequent replacement requirement of 120,000 a year. It is interesting to note that should British companies gain only 5 per cent. of the initial order it would represent the bulk of tractor exports in 1956. Unless the embargo on trade with China is lifted very shortly, however, Britain stands to lose much of this valuable business. Mr. Man warned at the time that since details of China's mechanisation plan had been settled, there would be little chance for British companies unless tenders were submitted in the near future. It certainly seems paradoxical that while the U.S.S.R. has been placing large orders for agricultural machinery in the United States during 1956, an embargo is still in force restricting trade with another communist country, and it is quite possible that this situation will be remedied in 1957. If it is, then British manufacturers can look forward to a profitable market in the Far East. It would indeed be welcome if only to counteract the falling off in trade with the Near Eastern countries which has occurred as a result of the political situation.

Meanwhile, British engineers have not been lagging in the field of technical advance, itself a necessary factor for maintaining and increasing sales. Among the new tractors appearing in 1956 were the Ferguson "35," developed by Massey-Harris-Ferguson, Limited, and the David Brown DB900, which made its debut at the Smithfield Show held at Olympia last December. Both these machines represent a considerable advance in design and performance, saving operational time and lowering working costs. Probably the most notable feature about the DB900 is its very low-geared steering, which is claimed to give a turning radius of 7 ft. 8 in. in each direction.

Probably the most interesting development in recent years, however, has been the practice of large companies to manufacture complete "systems" of machinery, in which the power for a comprehensive range of implements is supplied by the tractor. While these developments are a necessary concomitant to economic advance, however, they give rise to certain endemic problems. One of these is the high capital cost of such "systems." The major drawback, however, is that there has as yet been no move by the agricultural machinery industry to standardise such systems. ENGINEERING commented on this in last year's Outlook article (vol. 181, page 118, 1956), and other commentators have been outspoken during the past year. Farmers may not—especially at the present time—be able to afford expensive ranges of machinery, but may well want to buy one or two units now and add to them later. Lack of standardisation may, however, make the use of their existing machinery impossible or extremely difficult. Both from the point of view of the manufacturer, and the buyer, standardisation would be profitable.

To sum up, it is possible that 1957 will be a year more of consolidation and quiet development, rather than one of rapid expansion in the agricultural machinery industry.

LOCOMOTIVES AND ROLLING STOCK

The outlook for locomotive builders in the current year contains a number of uncertainties. While the production of steam locomotives continued to fall in 1956, this was more than counterbalanced by the growing production of Diesel and Diesel-electric locomotives which reached record figures. While this prosperity continued to be based mainly on export markets, the pilot orders placed at the end of 1955 by the British Transport Commission constituted a significant proportion of the work on hand. Towards the end of 1956 some anxiety was felt regarding the future of exports of locomotives since no large export orders had been received comparable to those obtained in 1954 and 1955. Nevertheless, although order books shortened during the year, most of the large locomotive builders had upwards of 12 months' work in hand which, even in the absence of a recovery in export orders, should be sufficient to carry them forward until a decision is reached regarding the allocation of the main body of orders to be placed by the British Transport Commission. Over the whole period of the modernisation programme these are expected to amount to 3,600 main line Diesel and electric locomotives, valued at about £185 million. In addition, there are included in the programme 1,200 Diesel shunting locomotives, costing a further £25 million, and 4,600 Diesel multiple-unit vehicles.

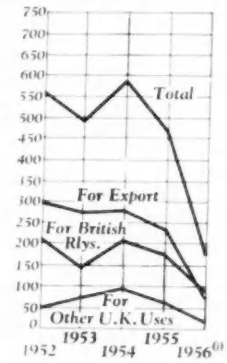
The pilot scheme orders comprised 141 main line Diesels and 30 power units. The bulk of these are expected to be completed during the second half of 1957, and the different specifications offered by the various manufacturers will then be subjected to extensive tests before a final decision is reached regarding the types most suitable for British Railways. If these tests are protracted, the locomotive industry may possibly be faced with a somewhat uncomfortable interregnum at the end of 1957 and in the beginning of the following year; in any case there is still some anxiety regarding the proportion of the orders which is likely to be allocated to the private locomotive builders as opposed to the Railway Workshops.

The White Paper issued by the Minister of Transport in the closing months of 1956 contains indirectly a good deal of reassurance on these points. In order to speed up the modernisation programme, the Government is empowered to grant loans to the British Transport Commission to cover annual deficits up to the early 1960's, by which time it is expected that the benefits of the plan will be felt in operating costs and conditions. If this is to be achieved it is clear that there can be no long delay in the placing of orders and that the latter must be sufficiently large to occupy an appreciable proportion of the capacity of the private locomotive builders, whatever decision is taken regarding new construction in the Railway workshops.

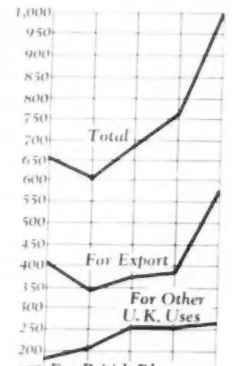
OVERALL EXPORTS STEADY

As can be seen from Table III, total exports of locomotives are estimated to have shown little change between 1955 and 1956, the decline in the value of steam locomotives exported being almost exactly offset by the rise in the value of exports of Diesel and Diesel-electric locomotives. The proportion of total exports accounted for by steam locomotives has been falling for several years, and in 1956 was only about 24 per cent. Taking all locomotives together, the most important markets in the first nine months of 1956 were Australia, New Zealand, the Union of South Africa and the Irish Republic. Among foreign countries the most important market was the Netherlands, to which exports were valued at £921,000 in the first three-quarters of the year, compared with only £341,000 in the corresponding period of 1955. Spain, Iran and Brazil, which were important markets in 1954, have very greatly reduced their imports from this country in the last two years, and in the first nine months of 1956 Commonwealth countries (including the Irish Republic) accounted for nearly 90 per cent. of total locomotive exports by value.

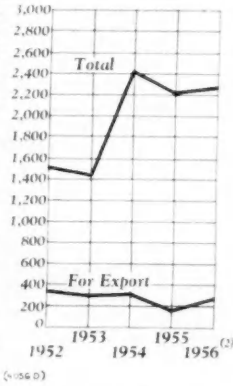
Although locomotive builders have experienced strong competition in export markets, the decline in new export orders appears to have been due as much to a fall in expenditure on new equipment by overseas railways as to the loss of orders to foreign competitors. The latter has nevertheless been an important factor and extremely low (and possibly uneconomic) prices have been quoted by locomotive builders in Japan and certain Iron Curtain countries. Speaking at the annual general meeting of the company in May last, the chairman of the North British Locomotive Company quoted some of the prices submitted for a particular locomotive in response to inquiries from the Indian Govern-



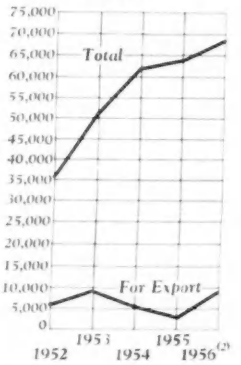
Steam locomotives.



Diesel and electric locomotives.



Coaching vehicles.



Wagons.

(1) Estimated on 1st six months
(2) Estimated on 1st nine months

United Kingdom production of locomotives, coaching vehicles and wagons, 1952 to 1956.

TABLE III.—UNITED KINGDOM EXPORTS OF LOCOMOTIVES AND ROLLING STOCK

	Quantities (tons)			Value (£1,000)		
	1954	1955	1956(a)	1954	1955	1956(a)
Complete locomotives:						
Steam	32,149	22,548	13,753	11,035	7,001	4,271
Others	14,360	17,271	20,140	7,586	10,646	13,268
Railcars	2,849	1,190	1,377	1,521	1,013	1,203
Railway Carriages complete	8,105	5,685	5,577	2,710	2,255	3,435
Wagons and trucks, complete	59,275	35,167	23,271	7,038	4,408	3,009
Parts of railway vehicles:						
Axles, tyres and wheels	53,749	84,371	75,977	4,115	6,384	5,943
Other n.e.s.:						
For railway carriages	3,066	1,823	3,023	1,429	1,044	1,365
For wagons and trucks	18,942	11,368	44,137	2,568	1,592	5,145
Others	19,253	16,658	18,421	6,314	6,109	7,016
	211,748	196,081	205,676	44,316	40,452	44,655

(a) Partly estimated.

ment. The British price, which it was stated contained virtually no profit, was £38,870 and the German price slightly higher. The Japanese tender, at £30,500, was the lowest, and tenders were received from Poland, Hungary, and Czechoslovakia, ranging from £31,250 to £31,862. In another instance, for a similar locomotive, Japanese builders quoted a price approximately £7,500 per locomotive less than they had themselves stated 2½ years earlier, and it was difficult to escape the conclusion that the quotations from Japan and the Iron Curtain countries contained an element of subsidy.

Both India and Argentina are potentially important buyers of locomotives. The former called for tenders in November, 1956, for 100 Diesel-electric locomotives of 2,000 to 2,400 h.p., required for the large modernisation programme of the Indian Railways. In August, 1956, it was reported that the Argentine Government had authorised the Ministry of Transport to buy 100 locomotives valued at 20 million dols. It was stated that 50 would be bought in the United States, 25 in France and the remainder in other European countries. At about the same time Indonesia ordered 60 locomotives from Germany and a further 35 from the United States. Subject to the availability of foreign currency and the capacity of the domestic locomotive building industry, the buying programme of the Argentine railways over three years 1956 to 1958 has been announced as 463 Diesel-electric locomotives and 300 motor coaches.

The South African Railways have embarked on heavy capital expenditure on electrification covering 445 route miles. Paradoxically one of the main objects of the electrification programme is to accelerate coal deliveries from the coal producing areas, and it is proposed to electrify all the lines serving the Transvaal coalfields. The English Electric Company has been responsible for the supply of 60 electric locomotives to the South African Railways and a further 100 similar locomotives are required under the plan. Another important order received by English Electric was for 12 2,000 h.p. Diesel-electric locomotives for Rhodesia.

ROLLING STOCK

Manufacturers of rolling stock were also busy in 1956, the output of passenger coaches being approximately the same as in the previous year, while output of wagons increased by about 6 per cent. The bulk of this output was for home use, and production for export amounted to only 12 per cent. of the total in the case of coaches and 9 per cent. in that of wagons. In April, 1956, the British Transport Commission announced that British Railways would spend £23 million on Diesel multiple-unit trains and £26 million on other passenger stock over the next two years. Of 70,000 freight wagons to be built in 1956, 47,500 were to be supplied by contractors and the remainder from the railway workshops.

Following a fall between 1954 and 1955, exports of complete passenger coaches are estimated to have risen from £2·3 million in 1955 to about £3·4 million in 1956. Exports of complete wagons and trucks on the other hand have been falling steadily, and in 1956 amounted to less than half the figure for 1954. This decline has, however, been largely offset by increased exports of parts of wagons and trucks, a trend which is probably associated with the growing production of wagons overseas. This tendency also affects other classes of rolling stock; in September, Israel reported the completion of the first locally-produced passenger coach and in the following month an agreement was announced between the Hindustan Aircraft Factory, Bangalore, and Maschinenfabrik Augsburg Nürnberg, for the production in India of lightweight metal coaches at a rate which is expected to reach 300 a year by 1961.

As in the case of locomotives there appears to have been a decline in the numbers of large overseas orders for rolling stock, but in December 1956, the Gloucester Railway Carriage and Wagon Company, Limited, announced that they had secured a contract valued at £1 million for the supply of 78 passenger coaches to Rhodesia Railways. This company, together with other builders of rolling stock, has complained that output during 1956 was hampered by shortage of steel and other raw materials. Some alleviation of this shortage may possibly occur in 1957 as a result of increased steel production capacity and possibly of a fall in demand elsewhere. It will certainly be unfortunate if as a result of raw material shortages the rolling stock industry should again acquire a reputation for long delivery delays at a time when foreign competition is intensifying. The industry is also very concerned at the trend of manufacturing costs. Speaking at the annual general meeting of the Birmingham Railway Carriage and Wagon Works in May, 1956, the chairman said that although the amount of work on hand was very large, the bulk of the orders, particularly for overseas, had been taken against severe competition, frequently at firm prices which precluded recovery of any increased costs.

The outlook for 1957 for both locomotive and rolling stock builders is thus one of a high level of output shaded by some anxiety regarding both the volume of available export business and the profitability of such export orders as can be secured. Insofar as competition in the case of locomotives is largely from Japan and the Iron Curtain countries, there may be little relief during the current year, and locomotive builders must inevitably pin their hopes on securing a substantial share of the orders to be placed by the British Transport Commission, but even if substantial orders are obtained from this source a recovery in export orders will be required if a high level of production is to be maintained.

MACHINE TOOLS

There was an appreciable change in the position of the machine-tool industry during 1956. Though some of the external factors limiting the expansion of the industry remain, there has been some increase in output, partly due to the slight easing of the labour shortage as a result of the Government's anti-inflationary measures. The latter have also begun to affect new orders for machine tools from the home market, and as a result of these two influences the value of orders on hand began to decline in the second half of the year. Provided it is not allowed to go too far, however, this decline is not an unwelcome development since for a number of types of machine tool the point had been reached at which export business was being discouraged owing to the long delivery quoted.

At the end of 1955 orders in hand stood at £100·2 million, an increase of nearly 24 per cent. over the figure at the end of 1954. This represented, on average, 16 months' output at the current rate of production, compared with just under 15 months for the previous year, though there were of course wide variations in the figures for different types of machine tool.

Although deliveries during the first eight months of 1956 were running at a monthly rate some 10 per cent. higher than during the same period in 1955, new orders were being received at a still higher rate with the result that the value of outstanding orders rose to a peak of £105 million at the end of June. The rate of increase had however been slackening steadily, and orders in hand started to fall in July.

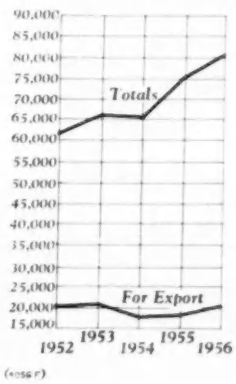
During the third quarter of the year, which normally shows a seasonal decline in output, deliveries rose by 12½ per cent. over the second quarter, and by the end of September, orders on hand had fallen to £102·9 million. The main immediate cause of the shortening delivery dates has been a fall in home orders, accompanied in some cases by cancellations of orders already placed. The credit squeeze has, of course, been fairly selective in operation, and makers of machine tools for most heavy industries have so far been little affected. Delivery dates for some semi-standard light machines, however, had by October come down to a fortnight, though periods of up to two years were still being quoted for multi-spindle automatics.

Manufacturers of domestic appliances were among the first to be affected by the credit squeeze, and a fall in orders for machine tools from this source was followed by a general slackening of demand from the light and medium engineering industries. More serious cuts have, however, come from the motor-vehicle industry —which for the last few years has been one of the principal purchasers of machine tools. So far these cuts apply less to the car-assembly plants than to the multitude of component manufacturers; the former have major modernisation and rationalisation schemes on hand which appear in the main to be continuing, though in some cases at a reduced rate. The latter, dependent on current vehicle output, have been hard hit, and it is in this field that the most serious drop in machine-tool orders (including some cancellations) has occurred.

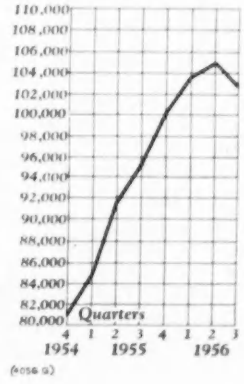
The motor-vehicle industry is now of course faced with a more severe setback than that imposed by the credit squeeze, and it remains to be seen how permanent the effects of this will be. If petrol rationing extends much beyond the first four months of the year, some considerable cutback in investment is to be expected even from the car-assembly companies. This may, however, be offset to some extent by reviving demand from the component manufacturers, if the latter are successful in their search for alternative products. It is virtually certain, however, that the machine-tool industry must reconcile itself to a considerable fall in demand from the motor industry as a whole, compared with the exceptionally high level of the last few years.

LABOUR SHORTAGE

Up to the middle of 1956, the machine-tool industries continued to suffer from shortages of skilled labour, technologists and draughtsmen, and also of special steels. It is paradoxical that while the industry has been dependent on the motor manufacturers for a high proportion of its orders, the latter should in recent years have been the principal cause of the shortage of labour which has been a major handicap to machine-



United Kingdom deliveries of machine tools in £1 thousand totals and exports (1956 figures partly estimated).



Value of machine tool orders on hand in £1 thousands.

TABLE IV.—*United Kingdom Exports of Metal-Working Machine Tools, 1954 to 1956*

	Quantities (1,000 cwt.)			Value (£1,000)		
	1954	1955	1956 (a)	1954	1955	1956 (a)
Totals	779	827	835	20,237	20,825	22,318
Including:						
Union of South Africa	67	61	52	1,518	1,463	1,340
India	83	105	105	1,998	2,408	2,518
Australia	136	136	134	3,587	3,704	3,736
Canada	64	50	68	1,540	1,234	1,827
Soviet Union	13	41	51	259	619	758
Sweden	18	22	36	520	703	984
Western Germany	6	27	21	267	424	602
France	36	45	54	1,105	1,552	1,723
Italy	39	35	9	1,446	837	369
United States of America	35	31	47	944	914	1,311

(a) Partly estimated.

tool makers. Though the shortage of labour was still reported as being acute during the first half of 1956, the labour market in the major producing areas has since become somewhat easier. There is, however, a limit to the effect that the motor vehicle recession can have in this respect, since it is primarily skilled labour which the machine-tool makers need, and the motor industry may be expected to make every effort to retain such labour as long as possible.

The continuing shortage of steels in general, and of nickel-alloy steel in particular, and extended delivery dates for such items as forgings are in some ways more serious, since they may be a determining factor as regards machine-tool delivery dates, which no advance in productivity can circumvent.

The struggle for technical staff continues unabated, and manufacturers have to face competition for technologists and draughtsmen, not only from such expanding industries as aircraft, but also from American manufacturers who offer considerably enhanced salaries. This is particularly serious, since it is ultimately on technical progress that the competitive strength of British manufacturers in foreign markets depends. It may be some small consolation, that America is also drawing German technologists away from Europe.

The export order position remains good, and as a result of the complex home disturbances, machine-tool makers should be in a position to offer better delivery dates than has been possible for the past two years. While exports have continued to rise (for the first 10 months of 1956, the increase was nearly 11 per cent. on the same period in 1955), they are still somewhat below 30 per cent. of production. Delivery dates are a very real brake on export expansion. There have been some shifts of emphasis in the pattern of trade. Over the first nine months of the year exports to Australia have shown a continued slight decline for the past three years; exports to South Africa have also shown a steady fall. Exports to India and Canada in the Commonwealth, and to France and Germany showed considerable increases in 1956 compared with the previous year. Sales to the United States also show a welcome increase, while in the early part of the year there were indications of growing trade with the U.S.S.R. The sharp decline in exports to Italy underlines the emergence of that country as an increasingly powerful competitor in international trade.

On the debit side, imports have risen considerably. In the first ten months of 1956, they amounted to £20·3 million, more than 50 per cent. higher than during the same period of 1955, and for the first time since 1953 exceeded exports.

German machine-tool output continues to expand and was expected to reach between £110 million and £130 million in 1956, including exports valued at between £45 and £50 million. With a backlog of orders in September of about £105 million, German manufacturers are in a position to offer average deliveries of 10 to 12 months. The delivery position is thus approaching that of the British industry and this may assist British manufacturers to expand exports in 1957.

AUTOMATIC CONTROL AND PRODUCTION

The third post-war International Machine Tool Exhibition held at Olympia in June and July, 1956, drew attention to two main trends. The first was the drive towards means for automatic production, both in transfer machines, and in the application of electronics to machine tool control. The second was the range of machines imported into the United Kingdom, not only of types not produced in this country, but also paralleling those produced by British manufacturers. The rise in imports in 1956 was largely due to the long delivery dates quoted by British manufacturers.

The application of electronics to machine tool control is gathering momentum. The E.M.I. system was referred to in this series of articles last year, and its application to two types of milling machine was demonstrated at the exhibition. The Ferranti system of computer control was shown for the first time, adapted for the production of three-dimensional milled components from instructions recorded on a magnetic tape. The complete computer set-up of this system is expensive, but one computer can serve at least eight machines, and it is anticipated that the number may in practice be as high as 50. This type of system is designed for the fully automatic production of components required in limited quantities, and is therefore most fully economic in the production of such items as jigs and templates. The reduction in manufacturing time possible, for instance, in jig-boring by the use of automatic positioning is very considerable. There is clearly scope for improved measurement and control systems, short of the fully automatic, but expensive, types quoted above. Among such systems demonstrated at the exhibition were those of British Thomson-Houston and Mullard.

This is a field in which British manufacturers can justly claim to be more than holding their own, and further rapid progress may be expected. In the field of transfer machines, there is perhaps more competition from abroad, but here again British manufacturers hold a strong position. The significance of these developments is perhaps greater for the user industries than for the machine-tool industry itself. The proportion of total engineering output suitable for fully automatic production has been the subject of considerable argument, but is probably not greater than 15 per cent. In this country, the automatic production of small batches is probably of more importance than mass production by transfer machines, and developments in computer control will probably make a significant contribution in the former field within the next few years, though probably not in the immediate future. Large machine-tool orders tend increasingly to comprise integrated groups of machines, particularly for the aircraft industry, where electronic controls are of great importance. In future development a factor of prime importance is likely to be the available supply of really able technologists with experience in this field.

Past experience has shown that if confidence in industry is seriously disturbed it may be reflected very rapidly in a sharp decline in orders for machine tools, and even in the cancellation of an imporant proportion of the orders already on hand. On the other hand there are undoubtedly good opportunities for expansion in export markets and the volume of orders on hand in most sections of the industry is still sufficient to ensure a high level of activity for several months. There appears to be a growing realisation that whatever the effects of the Suez crisis on the economy of the country as a whole, steps should be taken in the relatively near future to prevent any drastic decline in industrial investment at home and any such steps must help to maintain the home demand for machine tools.

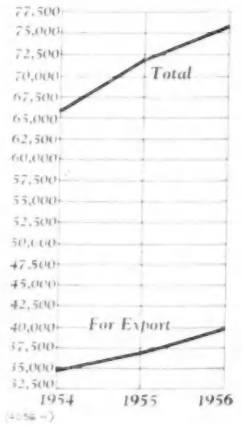
TEXTILE MACHINERY

Manufacturers of textile machinery are traditionally heavily dependent on the export trade. As shown in Diagram 5, while total deliveries have risen by 14 per cent. since 1954, deliveries for export have risen more rapidly over the last three years than those for the home market. In the year ending June, 1956, overseas deliveries accounted for 53 per cent. of the total. The greater part of the increase in export deliveries, however, took place in 1955, for, as shown in Table V, exports rose by only 4 per cent. in 1956, and in some types of machinery, notably looms and shuttles, overseas sales fell.

The brake on exports which characterised 1956 was, however, due less to a decline in the competitive strength of British manufacturers than to a fall in the demand for textile machinery in many traditional markets (with the notable exception of Asia). In September, 1956, the International Federation of Cotton and Allied Trades issued figures which showed that in the twelve months ending January, 1956, the number of looms installed in the world's cotton industry had fallen to 2,870,302, a decline of 19,127. In Western Europe, the fall amounted to 66,352 looms in the period under review. There was, however, a major increase in Asiatic countries, and it is also noteworthy that the number of automatic looms installed rose by 30,907. While these figures are concerned only with one particular type of textile machinery, they provide useful information regarding the trend of future demand, where that demand is to be found and the type of equipment needed to meet it. In the circumstances, it is somewhat disquieting to record that British exports to Asiatic destinations fell slightly during 1956, mainly as a result of a large fall in exports to Pakistan.

By contrast, it is encouraging to note that exports of textile machinery to Western Europe and the United States rose in 1956, although in the long run these may not prove the most profitable markets on which to concentrate major export efforts. Meanwhile, exports to other areas of the world, with the exception of the U.S.S.R., have declined. Russia is a potentially important market, particularly in view of a large £2 million order placed with a British company in 1956. In the short term, however, expanding exports to Russia may well be offset by the loss of the Egyptian market, to which exports in the first three quarters of 1956 were running at an annual rate almost exactly equal in value to the Russian order.

Given normal trading conditions, however, the textile machinery industry is confident of its ability to expand foreign sales. In the fields of design, technique, prices and delivery, the industry believes it is capable of meeting any overseas competition. Foreign competition is growing, and cannot be ignored, particularly from Switzerland, Germany, Japan and—more recently—from France, Italy and Czechoslovakia; the main difficulties in selling machinery abroad are however, associated with exchange control regulations in some countries, and the advantage derived by many competitors from the granting



United Kingdom: Deliveries of textile machinery, years ending June 1954 to 1956 (£1,000)

TABLE V.—United Kingdom: Exports of Textile Machinery, by Main Machinery Groups

	Quantities (1,000 cwt.)			Value (£1,000)		
	1954	1955	1956(a)	1954	1955	1956(a)
New:						
For making synthetic fibres	22	21	20	792	747	912
For spinning and twisting and preparatory processes	935	991	916	20,934	23,524	22,512
For processes preparatory to weaving but subsequent to spinning and twisting	65	62	56	1,842	1,869	1,636
Looms and other weaving machinery	254	255	276	4,089	4,584	5,208
Bleaching, dyeing, printing and other finishing	84	102	116	2,153	2,671	3,080
Hosiery and other knitting	52	54	56	5,152	5,371	5,948
All other textile machinery	59	55	72	1,902	1,905	2,444
Accessories separately consigned:						
Bobbins	7	7	7	280	264	300
Card clothing	18	20	23	975	1,063	1,332
Shuttles	5	6	5	242	261	244
Other	22	22	25	498	453	584
Secondhand	63	60	97	595	583	812
Total	1,586	1,655	1,669	39,454	43,295	45,112
Of which to:						
India	303	307	412	6,863	7,286	9,856
Pakistan	314	226	60	5,297	4,299	1,208
Australia	57	65	48	1,823	1,981	1,524
Union of South Africa	43	42	24	1,023	1,053	852
Other Commonwealth countries	65	71	120	2,020	2,135	2,396
Western Germany	51	55	52	1,816	2,130	2,212
Netherlands	54	42	44	1,265	1 020	1,184
Belgium	38	45	52	1,043	1,232	1,428
France	62	64	64	2,278	2,118	2,412
Italy	81	28	32	1,986	1,083	1,468
Other Western European Countries	166	141	152	4,652	4,107	4,584
Egypt	38	51	88	994	1,255	2,008
U.S.A.	25	54	56	1,017	1,932	2,254
All other countries	289	464	465	7,377	11,654	11,716

(a) Nine months' annual rate.

by their governments of subsidies or tax relief on goods produced for sale overseas. The hedge of exchange restrictions around many South American countries is an example of the former difficulty, and in this connection there have been notable declines in exports to such countries as Colombia, Venezuela, Chile, Brazil, Uruguay, and the Argentine. The latter problem may only be resolved if the GATT and O.E.E.C. regulations controlling these practices are respected more universally than is the case at present.

It is to be hoped, however, that there will be some relaxation in the future of exchange regulations, particularly in view of a further possible shrinkage in trade with Asia as a result of the closure of the Suez Canal. A further factor which may affect demand from some Far Eastern countries is the desire of some governments to set up their own sources of supply by encouraging local industry. Pakistan has provided one example of this trend in 1956, when the Punjab Rayon Mills Association of Lahore announced plans for the establishment of a factory to manufacture heddles and reeds locally. It is thought that output from the new plant will provide half Pakistan's requirements of this type of equipment. There is, however, little reason for British manufacturers to fear this trend, at least for several years ahead. The indigenous production of one type of machiney is often followed by a demand for more advanced types of equipment which cannot be produced from the resources available to local industry. British manufacturers, however, should not ignore investment opportunities abroad in this connection. Much of the technical know-how, and some of the financial assistance for the Pakistan project is to come from American sources, while a new textile machinery plant opened in Mexico early last year was the product of Mexican and Japanese financial co-operation.

TECHNICAL DEVELOPMENT ESSENTIAL

The development of the production of the simpler types of textile machinery in what were formerly important export markets, emphasises the need for British manufacturers to concentrate on technical development; there has been encouraging progress in this field, particularly as regards automatic machinery and equipment for working man-made fibres. Although 1956 was not characterised by any startling innovation, intensive research is justifying the heavy expenditure it involves. Such developments are not only essential for the export market; there is an urgent necessity for Lancashire to instal up-to-date machinery if the British cotton textile industry is not to experience a further decline. The Shirley Institute, set up to investigate and develop new designs of machinery for British mills, have done much good work in this connection, and Sir Raymond Streat, chairman of the Cotton Board, praised the work of the Institute when he addressed their annual meeting in July, 1956. Whether Lancashire, following the sharp revival of the cotton trade in recent months, will in fact be given the incentive to adopt new machinery on a wide scale remains to be seen.

Following the development of the newer textile machinery industries abroad, British manufacturers must certainly keep abreast of new technical developments if they are to retain an honourable place in markets abroad and at home. One of the most interesting developments in technology during the last two years, for example, has been a "shuttleless" loom manufactured by a Czechoslovak company. In 1956, these new machines have gone into regular production in that country and are claimed to be capable of weaving yarns at twice the speed of the orthodox loom. Water or air at high pressure is used in place of the conventional shuttle, and if all the claims made for the shuttleless loom are being fulfilled, it is certainly a big advance in design, since it is said to be capable of weaving up to 400 picks a minute, raises no dust, reduces vibration to a minimum and is cheap to build and easy to maintain. Currently the new looms are being used in Czechoslovakia for working man-made fibres, but it is hoped to develop future models suitable for weaving natural fibres. While no British loom has been developed along similar lines, there is evidence that the textile industry is interested. One weaver of cotton and synthetics has already purchased two shuttleless looms from Sulzer Brothers of Switzerland, and is experimenting with them at the present time. The Sulzer machines, weaving 200 picks a minute, operate at only half the speed claimed for the Czech loom, but the Rose Manufacturing Company (Ramsbottom), Limited, who have purchased the Swiss machines, believed that the innovation "would provide the answer to foreign competition in the textile trade."

Despite its achievements hitherto, the textile machinery industry abviously cannot afford to rest on its laurels. The year ahead will be difficult owing to the continued reluctance—or economic inability—of the British textile industries to instal new and up-to-date machinery. Also the loss of the profitable Egyptian market is a severe blow to the export trade. Nevertheless, it is in overseas markets that the long-term prosperity of the machinery industry lies, and it is therefore towards this market that it must direct the bulk of its efforts, both technical and economic.

COAL AND ELECTRICITY

In 1956 there was a very slight improvement in United Kingdom coal production compared with 1955. Preliminary figures suggest that the total output at about 222,500,000 tons may be up by just under 1 million tons.

The Suez crisis has created some doubts as to the extent to which oil can be relied on to fill the gap between present coal production and total energy requirements, and the need for higher coal production is now more pressing than ever. Estimates of total United Kingdom energy requirements suggest that some 325 million tons of coal equivalent may be required by 1965. At the highest estimate, atomic energy is unlikely to supply more than 15 million tons by that date, so that coal and oil must together supply more than 300 million tons.

While the effective labour force in coal-mining still fluctuates about a roughly constant level, increasing attention has been directed during 1956 to coal-face mechanisation. Power-loading in particular has been introduced at an increasingly rapid rate.

During 1955, the number of power loaders in use rose from 389 to 640, the tonnage handled being 26 million tons or 11·1 per cent. of total output. During 1956, the National Coal Board hoped to bring into use a further 700 and to raise the output so handled to 34 million tons. Several years of experiment and development have provided a choice of about a dozen well tested machines adapted to a wide variety of mining conditions, and it is expected that progress will now be rapid.

It is in power-loaders that the only significant increase in mining machinery production has been recorded, though there has been a steady rise in output of coal preparation plant, including appreciable exports during the first quarter of 1956. In spite of rapidly increasing production of power-loaders, however, the first three quarters figures do not suggest that the 1956 target will have been achieved.

In conjunction with the Anderson Boyes trepanner, promising results have been obtained from tests on Dowty self-advancing hydraulic roof supports. Present supporting systems are too slow for the power-loaders to work at full speed, and the introduction of remote controlled supports holds out the prospect of coal faces without men on them, utilising the new machines to the full. With the old system of supports, the trepanner improves productivity by about one-third; with a better supporting system the machine could get some 600 tons a day in place of 450, i.e., a further increase of about one-third. Output of hydraulic supports has been stepped up considerably.

Exports of mining and well-drilling machinery in the first three quarters of 1956 showed an appreciable increase over 1955, though the figure of £4,981,851, is still below that of £5,067,084 for the corresponding period of 1954. In particular, exports to India and Canada rose considerably, while those to the Union of South Africa continued the steady decline of recent years. India's requirements for mining plant under the second 5-year plan are estimated to amount to an annual rate of about £5½ million. The U.S.S.R. has offered to help India to set up a plant for the manufacture of mining machinery.

For the immediate future, the prospect is certainly one of growing home demand for mining machinery of all kinds, with particular emphasis on power-loaders and improved roof-

TABLE VI.—UNITED KINGDOM DELIVERIES OF COAL-MINING MACHINERY, ELECTRICAL PLANT AND MACHINERY, AND STEAM-RAISING PLANT

—	Unit	Total					For export				
		1952	1953	1954	1955	1956 (*a*)	1952	1953	1954	1955	1956 (*a*)
Coal mining machinery:											
Coal cutters	Number	775	968	991	931	884	143	215	108	89	98
Power loaders (*b*)	,,	43	63	99	104	324	2	3	4	5	32
Underground conveyors	,,	3,266	3,846	3,980	3,766	4,082	435	611	293	320	416
Diesel underground locomotives	,,	83	103	122	106	102	20	24	22	10	28
Coal preparation plant	£'000	6,020	8,832	9,797	11,169	11,438	942	1,367	386	219	584
Winding and haulage equipment	,,	4,292	4,844	5,727	6,909	5,988	1,554	1,124	766	731	734
Tubs and mine cars	'000 tons (*c*)	49·6	64·7	75·6	70·7	52·4	—	—	—	—	—
Electrical generating plant and machinery:											
Hydraulic turbines	Thousand B.H.P.	514·8	736·8	507·6	446·4	160·8	390·8	682·8	404·4	303·6	111·0
Steam turbo-alternators (10 MW and over)	MW	2,042·4	2,516·4	2,342·4	2,619·6	3,133·2	923·6	891·6	772·8	828·0	732·0
Steam turbines (less than 10 MW)	,,	352·8	190·8	214·8	192·0	55·0	191·6	73·2	98·4	78·0	24·2
Rotating electrical machines, 1-250 h.p., kVA or kW	£'000	29,424	29,352	27,108	31,548	34,045	5,940	5,256	5,292	6,012	6,417
Over 250 h.p., kVA or kW	,,	4,644	5,928	7,668	9,012	9,540	1,812	2,532	2,640	2,412	2,484
Steam-raising plant:											
Shell boilers	£'000	9,456	9,744	9,984	10,308	9,403	1,920	1,932	2,292	2,052	1,692
Steam-raising plant accessories—											
Fuel oil burners	,,	2,808	3,084	3,432	4,956	6,327	660	516	672	732	855
Other	,,	11,880	13,500	13,536	14,856	— (*d*)	2,424	2,508	2,292	2,100	— (*d*)

(*a*) Partly estimated. (*b*) Including cutter-loaders. (*c*) Carrying capacity. (*d*) Figures available for first 4 months only.

support methods. The limitation appears to be rather on the rate at which power-loaders can be produced than on the rate of absorption at the coal face.

ELECTRICITY INVESTMENT CURTAILED

The Central Electricity Authority spent £213 million on capital account during the year 1955-56, bringing into commission 1,665 MW of new generating capacity. Although it has been estimated that continued investment at this level is necessary to achieve the expansion of output the country needs, the C.E.A. have been compelled to reduce their estimates for the current year ending March 31, 1957, to about £195 million, by postponing some schemes. Up to 1960, the revised capital programmes run at a fairly constant rate, though in the years 1960 to 1963, with the first nuclear power plants coming into operation, the capacity to be commissioned is estimated to reach 2,350 MW a year. This estimate was, however, made before the recently announced intention to revise the nuclear power programme, and the revised total may well be higher than this.

The total home demand for heavy electrical plant is expected to continue at a high level, and electricity supply may therefore be expected to take a smaller proportion of the total output.

Steady progress is being made in raising the thermal efficiency achieved in power stations, the average figure for 1955-56 being 24·35 per cent. The present serious fuel situation necessitates increasing emphasis on thermal efficiency in all fields of fuel consumption and the demand for fuel saving appliances and automatic control systems is likely to expand.

The trend towards larger generating units continues. The latest C.E.A. programme includes a number of 275 MW turbo-generators, and a 550 MW turbo-generator is planned for the 1962 programme. The largest generators previously ordered for Great Britain were 200 MW.

In the export field, the major contract awarded was that for the Kariba dam. Although the main civil engineering contract, worth about £25 million, was secured by an Italian consortium, Metropolitan Vickers and English Electric secured orders for over £2¼ million worth of water turbine generators and power transformers. Exports of heavy electrical machinery have in general continued at a satisfactory rate.

The major event of 1956 in the field of power supply was of course the advent of nuclear power on a commercial scale. The opening of Calder Hall in October marked the end of ten years of planning, and the beginning of the practical era of atomic power generation. The construction of Calder Hall has demonstrated the practicability of many new techniques, and has shown advances in many old ones. Notable among the latter is the welding of thick plate, enabling much larger and stronger pressure vessels to be constructed than had been thought possible.

The Central Electricity Authority and the South of Scotland Electricity Board awarded contracts in December for the first three United Kingdom atomic power stations, and negotiations for a fourth were in progress at the end of the year. The total net generating capacity of the four stations will be 1,160 megawatts, equivalent to the electricity produced from 3¾ million tons of coal a year. There are now five major groups of companies formed for the construction of atomic power stations, and progress is limited more perhaps by the number of concerns competent to construct such stations than by technical problems.

Although no firm announcement had been made at the time of going to press, it was generally expected that a further expansion of the nuclear power programme would be announced after the reassembly of Parliament. It has been suggested that as a result of this revised plan probably at least 15 nuclear power stations will be in operation by 1965, with a total net generating capacity of 4,000 megawatts, instead of the 2,000 megawatts envisaged in the original plans. This is equivalent to about 13 million tons of coal a year.

FEWER SHELL BOILERS

Preliminary estimates for the 1956 output and exports of shell boilers show an appreciable decline from those for 1955. As forecast in last year's Outlook article (vol. 181, page 103, 1956), the effect of the credit squeeze must be to concentrate the prospects of the boilermaking industry very largely on the requirements of the Central Electricity Authority, and since the latter are also curtailing their expansion plans to some extent, some recession from the record level of output achieved in 1955-56 was to be expected. The struggle between the conflicting needs on the one hand of replacing worn out and inefficient plant in the interests of fuel economy, and on the other hand of reducing capital expenditure, is hard to resolve. In the long term, the national interest can hardly be served by the retention of inefficient plant, and several authorities have stressed the fact that it is much easier to save a ton of fuel by more efficient combustion than to mine an extra ton. In the present circumstances, this long-term problem has become much more immediate.

The problem is not made simpler by the fact that many of the fuel-saving devices involve a change to oil fuel. Packaged oil-fired boilers in particular were making considerable headway in this country up to the blocking of the Suez Canal. Output of oil burners has risen sharply since 1954, and until Suez, the prospects for 1956 were very good. In the latter part of the year sales dropped sharply, and it remains to be seen how far the confidence of industrial users will be restored after the reopening of the Canal.

The outlook for the year 1957 and beyond can therefore be summed up in the following words.

There is a pressing need for more efficient modern coal burning plant. While coal output can be and is being increased, progress is bound to be slow, in spite of an increased rate of mechanisation. The home market for mining machinery should undoubtedly continue at least at its present level, and will probably expand in the power-loading and roof supporting fields. The home demand for heavy electrical machinery may show some decline over the next few years, though this may well be offset by upward revision of the nuclear energy programme.

Since coal putput cannot be rapidly expanded, the atomic energy programme will probably be revised upwards more than once over the next few years. In spite of this, however, the national dependence on oil cannot but grow, and output of oil burning systems should continue at a high level after the present crisis has abated. The 1957 output of such systems will, however, almost certainly show an overall drop.

★ ★ ★

INDIVIDUAL MOTORS IN QUARRY PLANT

An increase in the efficiency and output of the crushing and screening plant which has been installed in a quarry belonging to X.L. Granite (Ingleton), Limited, on the slopes of Ingleborough in north-west Yorkshire, has been obtained by the use of individual drives for the different machines. The electrical plant for this purpose was supplied by Crompton Parkinson, Limited, Aldwych, London, W.C.2.

The granite is loaded by hand into 30 cwt. skips, a practice which allows it to be separated from the earth; and is then taken in lorries to the crushing plant where it is discharged into a 10 ton hopper. After passing through various crushing and screening plant it is graded into six sizes from ¾ in. down to dust, and stored.

A supply of power for operating the plant is obtained from the public mains at 11 kV through an underground cable, which is connected through a circuit-breaker to a 300 kVA, 11 kV/433 volt three-phase transformer. The low voltage side of this transformer is connected through 25 MVA switchgear to a distribution board from which the main motor sequence control panel is fed. This panel controls interlock and contactor gear, which is arranged so that the nine motors driving the conveyor and screening plant are started in the proper sequence. It also ensures that if any of this equipment fails the preceding items in the system will be stopped in order to halt the flow of material.

A 10 kVA comparator is employed for all motors on the automatic panel, thus enabling the power factor to be maintained at an average of 0·96 lagging.

VIRTUAL WORK AND THE MOMENT DISTRIBUTION METHOD

DETERMINATION OF SWAY MOVEMENT IN FRAMES

By B. G. Neal, M.A., PH.D., A.M.I.C.E.*

In applying sway corrections in a moment distribution analysis of a complicated framework, it is necessary to analyse the geometry of each possible independent sway movement. The correct amount of each sway movement which actually occurs is then determined by ensuring that the appropriate equations of equilibrium are satisfied. Previous accounts of methods of analysis to deal with sway have, with one exception, treated the derivation of these equations of equilibrium by ordinary statical procedures.

The object of the present paper is to explain how these equations can be derived directly from the geometry of the sway movement by an application of the Principle of Virtual Work. This results in a shortening of the labour involved, and is believed to lead to a much closer understanding of the process of sway correction. The underlying principles involved are first explained with reference to a simple example, and the method is then applied to obtaining a solution for a single-bay pitched-roof portal frame.

In applying the moment distribution method to the analysis of frames which sway under the action of the applied loads, it is necessary to determine (not always explicitly) the amount of sway movement which takes place in order that the appropriate conditions of equilibrium should be satisfied. In a method of solution due to Matheson,[1] the number of independent sway movements which are possible is first determined. The geometry of each sway movement is then analysed, and the fixed-end moments induced in the members due to a sway movement of arbitrary magnitude, in which each of the joints is held fixed against rotation, are computed. Keeping the joints fixed against any further translation, the moments are then distributed until each of the joints is balanced. The fixed-end moments induced by the applied loads when each of the joints is prevented from translation are also computed, and the bending moments occurring when these moments are distributed are then found. The determination of these bending moment distributions constitutes the first step of the analysis.

The second step is to set up the equations of equilibrium which must be fulfilled by the actual distribution of bending moment. This is normally done by conventional statical procedures, the number of equations which must be established being equal to the number of independent sway movements.

Finally, the correct distribution of bending moment is obtained by adjusting the amounts of sway which were assumed to occur in the various sway solutions. Each of these solutions must be multiplied by an appropriate factor, these factors being chosen so that when the corresponding sway distributions of bending moment are added to the no-sway distribution, the resulting bending moments satisfy all the appropriate conditions of equilibrium.

The primary object of this paper is to point out that once the geometrical analysis of the sway movements has been carried out, the required equations of equilibrium can be derived immediately by applying the Principle of Virtual Work, thus reducing very considerably the amount of labour involved in the second step of the analysis. In fact, it can be said that there is an equation of equilibrium corresponding to each sway movement, and a systematic technique for the determination of the correct number of equilibrium equations, and thus of sway movements, is also presented. This technique is already used as a preliminary to the kinematical method of analysis that is used for determining the plastic collapse load of framed structures[2].

It cannot be claimed that the idea of obtaining equilibrium equations by using the Principle of Virtual Work is new, for this use of the Principle underlies the kinematical method of plastic analysis[3]. Specific derivations of equilibrium conditions by the Principle have been given by Neal and Symonds[4], and also by Prager[5], and in a recent paper on the moment distribution method by Clyde[6] it was also pointed out that the equations of sway equilibrium could be derived from the geometry of the sway movements by making use of the Principle of Virtual Work. However, the analytical technique advocated by Clyde consisted of a continual adjustment of the sway movements as the analysis proceeded, whereas in the present article the sway corrections are made by Matheson's method at the end of the analysis. In view of this difference in approach, and because the use of the Principle of Virtual Work calls perhaps for a more extensive description than was given in Clyde's article, it was felt that the publication of this present article would fulfil a useful purpose.

The method advocated here has been well tried insofar as it has been taught to honours students at the University College of Swansea for the past two years.

SIMPLE EXAMPLE

The basic principles involved will be explained first with reference to the elementary problem illustrated in Fig. 1(*a*). In this frame all the members are supposed to have the same flexural rigidity, the feet of the stanchions are rigidly built in at A and E, and the joints at B and D are rigid. For this frame only one sway movement is possible, this being the simple sidesway movement shown in Fig. 1(*b*). The sway is imagined to take place in the first instance with the joints B and D prevented from rotating, as shown in the figure. The geometry of this movement is solved very simply by noting that the lateral displacement δ at the top of each stanchion must be the same, since the length of the beam B C D remains unaltered. Each stanchion is bent into the double curvature shape shown, and this requires the imposition of counter-clockwise moments at the tops and bottoms of the stanchions of magnitude S, where

$$S = \frac{6EI\delta}{l^2} \quad . \quad . \quad . \quad (1)$$

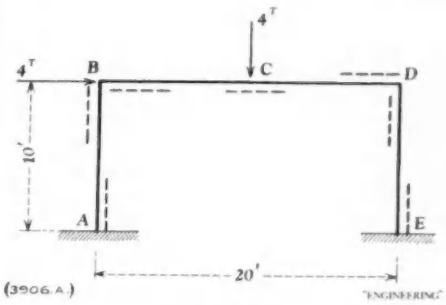


Fig. 1a

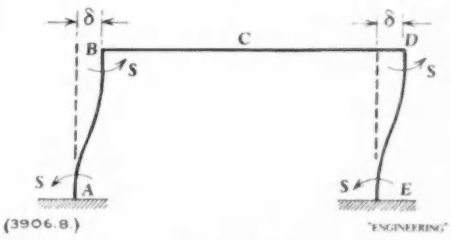


Fig. 1b

Fig. 1 A simple rectangular frame, illustrating the most elementary sway movement that is possible.

If no sway took place under the applied loads, the bending moments in the frame would be determined first by imagining the loads to be applied with the joints B and D fixed against both rotation and translation. The horizontal load 4 tons would then have no effect owing to the prevention of translation, and the vertical load 4 tons on the beam would give rise to fixed-end moments of magnitude 10 ton-ft. at B and D. The usual process of moment distribution would then lead to the determination of the bending moments in the frame, the joints B and D then having rotated by amounts which led to rotational equilibrium of these joints while their translation was still prevented. The bending moments thus obtained, which are denoted by M_0, are given in the first row of Table I, below.

In this table the usual sign convention is adopted, that a bending moment is positive when it acts in a clockwise sense on the member. This sign convention is summarised conveniently by the introduction of the dotted lines in Fig. 1(*a*), a bending moment being regarded as positive if it causes tension in the extreme fibres of the member adjacent to the appropriate dotted line. The notation is also conventional, the first letter indicating the section concerned and the second letter indicating the far end of the member on which the moment acts.

It is at once evident that the set of moments M_0 cannot satisfy the condition of sidesway equilibrium for this frame, for these moments would be correct if there were no applied horizontal load. The equation of sidesway equilibrium is derived very simply by noting that the horizontal load of 4 tons applied at D must be carried by the sum of the shear forces in the two stanchions, so that

$$-\left(\frac{M_{AB}+M_{BA}}{10}\right)-\left(\frac{M_{DE}+M_{ED}}{10}\right)=4$$

$$-M_{AB}-M_{BA}-M_{DE}-M_{ED}=\Sigma M=40 \quad (2)$$

with an obvious notation, the summation of moments in the left-hand side of equation (2) being defined as ΣM for convenience.

The value of the summation ΣM for the set of moments M_0 is readily seen to be zero from the entries in the table, and this value of ΣM is recorded in the last column.

In order to determine the actual set of moments, for which the value of ΣM must be 40 ton-ft., it is necessary to add to the set of moments M_0 those moments arising from the sidesway of the frame. Since the amount of sidesway is not known, the moments corresponding to an arbitrary sidesway are first computed. An arbitrary choice of the sidesway clearly corresponds to an arbitrary choice of the initial sway moment S, from equation 1, and it is usual to choose S as a round number, say 10 ton-ft.,

TABLE I.

Section	AB	BA	BD	DB	DE	ED	ΣM
M_0	4	8	−8	8	−8	−4	0
M_1	−7·14	−4·29	4·29	4·29	−4·29	−7·14	22·86
M	−8·5	0·5	−0·5	15·5	−15·5	−16·5	40

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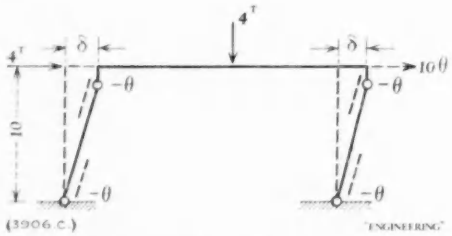


Fig. 2 The sway mechanism corresponding to the sway movement of Fig. 1b.

without actually computing the value of δ. The set of bending moments M_1 corresponding to this choice of S, which is obtained after the joints are balanced in the usual way, is given in the second row of Table I.

The value of the summation ΣM for the set of moments M_1 is found to be 22·86 ton-ft. These moments must now be multiplied by a non-dimensional factor λ_1, and added to the set of moments M_0, so that the actual bending moment M at any section is given by

$$M = M_0 + \lambda_1 M_1. \quad . \quad . \quad (3)$$

The value of λ_1 is then chosen so that equation (2) is satisfied. This procedure amounts to adjusting the arbitrary sway corresponding to the arbitrary choice of S by the same factor λ_1.

To determine λ_1 it is noted that, from equations (2) and (3),

$$\Sigma M = \Sigma (M_0 + \lambda_1 M_1)$$
$$= \Sigma M_0 + \lambda_1 \Sigma M_1 = 40. \quad (4)$$

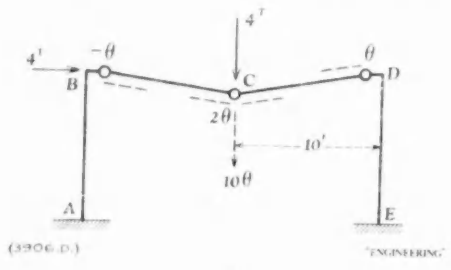
Since from Table I, $\Sigma M_0 = 0$ and $\Sigma M_1 = 22{\cdot}86$, it follows that

$$22{\cdot}86\ \lambda_1 = 40,$$
$$\lambda_1 = 1{\cdot}75.$$

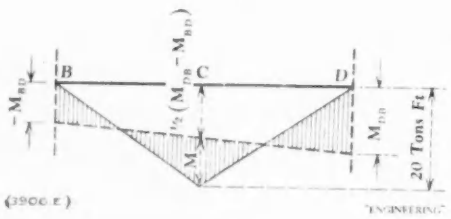
Thus at each section the actual moment M has the value $M_0 + 1{\cdot}75\ M_1$. The third row of Table I gives the values of M.

APPLICATION OF PRINCIPLE OF VIRTUAL WORK

The geometry of the sway movement for the frame of Fig. 1(*a*) is embodied in Fig. 1(*b*). In this figure it will be seen that the distance between the ends A and B of the stanchion A B only changes by an amount which is of the second order of small quantities in δ, and is thus



(a)



(b)

Fig. 3 Equilibrium of the beam: the virtual work done by the movement of the load is absorbed by the hinges. The bending moment diagram for the beam (b) is the difference between the diagram for a simply supported beam and the diagram for the end moments plotted with reversed sign.

negligible. Thus the essential features of the sway geometry in respect of the movements of the joints are preserved if the sway is imagined to take place by the rotation of hinges at the tops and bottoms of the stanchions while the stanchions themselves remain straight, giving rise to the sway *mechanism* shown in Fig. 2. In this figure the sign convention adopted for the hinge rotations is that a positive rotation causes extension in those fibres adjacent to the dotted lines in Fig. 2, this convention being a consistent counterpart of the convention adopted for bending moments which is summarised in Fig. 1(*a*). The hinges at B and D are shown, for the sake of clarity, a short distance away from these joints, but they are actually supposed to be located immediately below these joints.

If the mechanism motion of Fig. 2 is imagined to take place under quasi-static conditions, with the rotation at each hinge resisted by a bending moment such that equilibrium is preserved, a simple application of the Principle of Virtual Work at once leads to the equation of sideway equilibrium. During this imaginary motion of the sway mechanism the horizontal load 4 tons moves horizontally through a distance 10θ ft., the virtual work done thus being 40θ ton-ft. The downwards movement of the vertical load 4 tons is only of the second order of small quantities, so that the virtual work done by this load is negligible. The total virtual work done is thus 40θ ton-ft., and this must be balanced by the virtual work absorbed at the four hinges. At each hinge the virtual work absorbed is the product of bending moment and the angle turned through, since the sign conventions for angle and moment are consistent. It follows that

$$-\theta M_{AB} - \theta M_{BA} - \theta M_{DE} - \theta M_{ED} = 40\theta$$
$$-(M_{AB} + M_{BA} + M_{DE} + M_{ED}) = 40,$$

this equation being identical with equation 2.

NUMBER OF INDEPENDENT SWAY MECHANISMS

In the simple example just considered it was at once evident that there was only one possible sway movement or mechanism. For more complicated frames there will usually be several possible sway mechanisms, and it is of importance to be able to determine the proper number to be taken into account. A set of sway mechanisms chosen arbitrarily might not all be independent, for it could occur that the hinge rotations and displacements of one of the mechanisms could be built up from the hinge rotations and displacements of two or more of the other mechanisms superposed in the right proportions. A set of sway mechanisms should be such that they are all independent, and that any possible sway mechanism can be built up by suitable combinations of the independent sway mechanisms.

An equation of sway equilibrium can always be derived by applying the Virtual Work method to a sway mechanism, so that an equation of sway equilibrium can be said to *correspond* to every sway mechanism. It follows that a set of sway mechanisms will be independent if the corresponding set of sway equations of equilibrium is also independent, in the sense that no one of these equations can be derived as some combination of the others. Furthermore, the number of independent sway mechanisms will be the same as the number of independent sway equations of equilibrium, so that a convenient way of determining the number of independent sway mechanisms is to determine the number of independent sway equations.

The number of independent sway equations can be found by computing the total number of independent equations of equilibrium and then determining how many of these equations are of the sway type. The number, *e*, of independent equations of equilibrium is found from the following relation

$$e = n - r. \quad . \quad . \quad . \quad (5)$$

where *n* is the number of bending moments required to specify the distribution of bending moment throughout the frame, and *r* is the number of redundancies. This relation merely expresses the fact that of the *n* bending moments which are to be found, *r* cannot be found from statical considerations, and therefore the remaining $(n - r)$ can be found in this way. There must therefore be $(n - r)$ independent equations of equilibrium.

Taking the example of Fig. 1 (*a*) as an illustration, it is noted that the bending moment must vary linearly along the four segments A B, B C, C D and D E, for the shear force is constant in each of these segments. The complete distribution of bending moment is therefore determined if the bending moments at the five sections A, B, C, D, and E are known. However, since at certain stages in the moment distribution process the moments at a joint such as B are unequal in the beam and the stanchion, it is correct to count two unknown bending moments at each of the joints B and D. It follows that the value of *n* is 7. The number of redundances *r* for this frame is 3, for if a cut is made at any cross-section and the values of the shear force, thrust and bending moment at this section are specified, the entire frame becomes statically determinate. It follows that

$$e = 7 - 3 = 4.$$

The four independent equations of equilibrium must now be identified, so that it can be decided how many of these equations refer to sway. For this purpose it is convenient to classify the equations as *joint*, *beam* and *sway* equations. Although it is only the sway equations which need to be written down in applications of the moment distribution method, all three types of

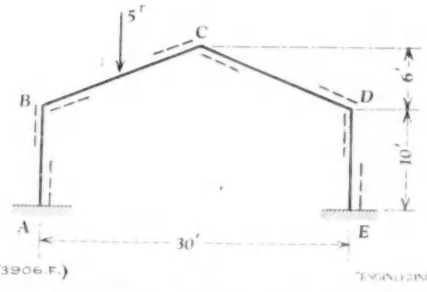


Fig. 4 Portal frame, with asymmetrical loading, the subject of the second example. This arrangement gives rise to two independent sway mechanisms, shown in Fig. 5 (a) and (b).

equation will be established here for the sake of clarity.

Joint Equations.—The joint B must be in rotational equilibrium, and it follows immediately that

$$M_{BA} + M_{BD} = 0. \quad . \quad . \quad (6)$$

Similarly, for the joint D,

$$M_{DB} + M_{DE} = 0. \quad . \quad . \quad (7)$$

Equations 6 and 7 are the two joint equations of equilibrium. Since in each moment distribution which is carried out the joints are balanced, these equations are automatically taken into account, and need not be considered further.

Beam Equation.—This equation relates the moments at the ends and at the centre of the beam B D to the applied vertical load of 4 tons. It is readily derived by applying the Principle of Virtual Work to the small motion of the *beam mechanism* shown in Fig. 3(*a*).

It can be seen from the figure that during this motion the horizontal load 4 tons does no virtual work, while the vertical load 4 tons, in moving through a distance 10θ ft., does virtual work 40θ ton-ft. Equating this virtual work done to the virtual work absorbed at the hinges, it follows that

$$-\theta M_{BD} + 2\theta M_C + \theta M_{DB} = 40\theta$$
$$-M_{BD} + 2M_C + M_{DB} = 40$$
$$M_C = 20 - \tfrac{1}{2}(M_{DB} - M_{BD}). \quad (8)$$

This equation merely expresses the elementary fact that the bending moment diagram for the

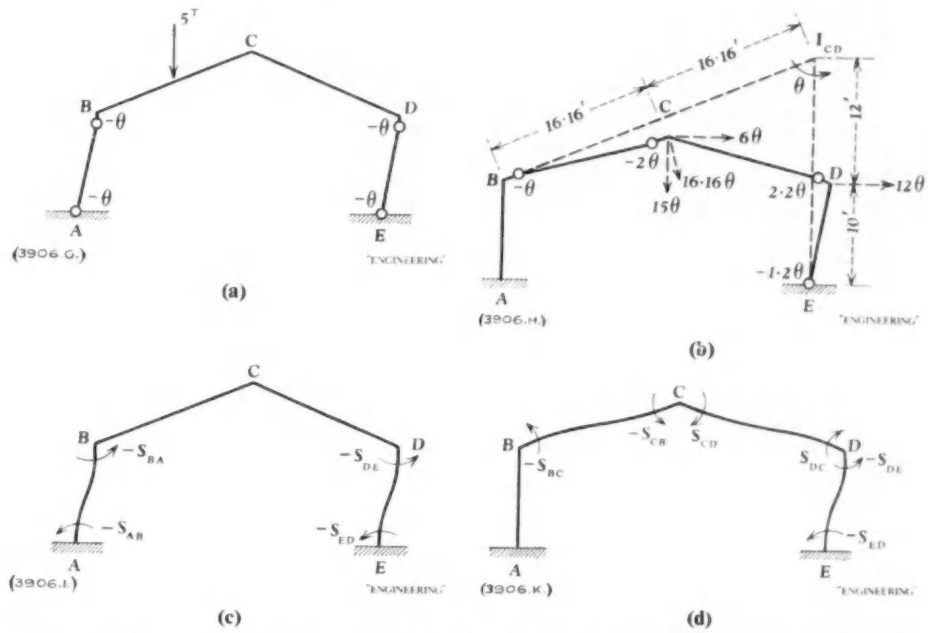


Fig. 5 The two sway mechanisms, (a) and (b), for the portal frame and the corresponding sway movements, (c) and (d).

beam can be regarded as the difference in ordinate between a free bending moment diagram, constructed as for a simply supported beam, and a reactant moment diagram due to the end moments alone, plotted with reversed sign, as slown in Fig. 3(*b*). This equation thus requires no further consideration in the moment distribution procedure.

If the loading on the beam B D had been more complex, consisting of several concentrated loads or even a uniformly distributed load, the complete bending moment distribution could still be determined by constructing free and reactant diagrams once the moments at B and D were known. In such cases any beam equations which were derived would still merely express this fact, and would thus be of no further use in the moment distribution procedure. This can be seen by supposing that there were N concentrated loads on the beam. The value of n would be N + 6, and the frame would still have three redundancies, so that

$$e = N + 6 - 3 = N + 3.$$

There would still be two joint equations of equilibrium and one sidesway equation, so that there would be N beam equations of equilibrium. The corresponding mechanisms would each be of the type shown in Fig. 3(*a*), with hinges at each end of the beam and a hinge beneath each of the loads in turn.

Sway Equation.—Two joint equations and one beam equation having been identified, there remains one other equation of equilibrium to be found. This is the sway equation, equation (2), which has already been derived by the Virtual Work method.

PITCHED-ROOF PORTAL FRAME

The method will now be applied to the case of the portal frame whose dimensions and loading are shown in Fig. 4. In this frame all the members are supposed to be of the same relevant moment of inertia.

The number of bending moments n required to specify the complete distribution of bending moment throughout the frame is nine, namely, two each at the joints B, C and D, one beneath the vertical load, and one at each stanchion base A and E. Since the number of redundancies r is three, it follows that

$$e = 9 - 3 = 6.$$

It can be seen by inspection that there are three joints B, C and D for which there must be equations of rotational equilibrium. The rafter B C is the only member subjected to load and so there can be only one beam equation, corresponding to this member. There must therefore be two independent sway equations and accordingly two independent sway mechanisms. These deductions are summarised as follows:—

Joint equations (joints B, C and D)	3
Beam equation (rafter B C)	1
Sway equations	2
Total	6

The two independent sway mechanisms may be chosen as indicated in Figs. 5(*a*) and (*b*). In the simple sidesway mechanism of Fig. 5(*a*), which will be referred to as Sway I, the whole roof only moves horizontally, so that there is no virtual work done by the vertical load. The corresponding equation of equilibrium is thus seen to be

$$-\theta(M_{AB} + M_{BA} + M_{DE} + M_{ED}) = 0$$

$$\Sigma_1 = -M_{AB} - M_{BA} - M_{DE} - M_{ED} = 0. \quad (9)$$

The kinematics of the mechanism of Fig. 5(*b*), which will be referred to as Sway II, are more involved. Since the rafter B C rotates about the end B, the apex C moves perpendicular to B C. The rafter C D must therefore be rotating about an instantaneous centre I_{CD}, which lies on B C produced. Similarly, the stanchion E D rotates about E, so that D must move horizontally. I_{CD} must therefore also lie on E D produced. It follows that the position of I_{CD} is as shown in the figure.

If C D undergoes a counter-clockwise rotation θ about I_{CD}, D moves horizontally through a distance 12 θ ft., as shown. The rotation of the hinge at E must therefore be of magnitude 1·2 θ, the length of E D being 10 ft. The apex C moves in a direction perpendicular to B C through a distance 16·16θ ft., and since the length of B C is 16·16 ft. the hinge rotation at B is of magnitude θ. Since B C rotates clockwise through an angle θ, and C D rotates counter-clockwise through the same angle, the magnitude of the hinge rotation at C is 2 θ, and by a similar argument the hinge rotation at D is seen to be of magnitude 2·2 θ. The signs of all the hinge rotations are readily determined by inspection. Finally, it can be seen that the vertical component of the movement of the apex C is 15 θ ft., and since B does not move, the vertical component of the movement of the centre of the rafter B C is 7·5 θ ft.

The equilibrium equation corresponding to this mechanism is thus seen to be

$$-\theta M_{BC} - 2\theta M_{CB} + 2{\cdot}2\theta M_{DC} - 1{\cdot}2\theta M_{ED} = 5 \times 7{\cdot}5\theta$$

$$\Sigma_2 = -M_{BC} - 2M_{CB} + 2{\cdot}2M_{DC} - 1{\cdot}2M_{ED} = 37{\cdot}5. \quad (10)$$

The two sway movements corresponding to the sway mechanisms are illustrated in Figs. 5(*c*) and (*d*). For the simple sidesway movement of Fig. 5(*c*) it is evident that the initial sway moments S_{AB}, S_{BA}, S_{DE}, S_{ED} are all equal. However, for the more complex Sway II of Fig. 5(*d*), reference must be made to equation I when assigning the relative magnitudes of the initial sway moments. This equation states that the initial sway moment S appearing at each end of a given member is given by

$$S = 6E\left(\frac{I}{l}\right)\left(\frac{\delta}{l}\right).$$

The term $\frac{I}{l}$ in this equation is the stiffness of the member, and will be denoted by K. The term $\frac{\delta}{l}$ is the relative lateral deflection of the ends of the member divided by its length, which is identical with the rotation ϕ of the member in the sway mechanism. If E is the same for all the members, it follows that

$$S \propto K\phi$$

The values of K and ϕ for the members B C, C D and D E involved in Sway II are as follows:—

	K	ϕ	Kϕ
B C	$\frac{I}{16{\cdot}16}$	θ	0·0619 I θ
C D	$\frac{I}{16{\cdot}16}$	$-\theta$	−0·0619 I θ
D E	$\frac{I}{10}$	1·2 θ	0·12 I θ

The initial sway moments are thus in the following ratios:—

$$S_{BC} : S_{CD} : S_{DE} = -6{\cdot}19 : +6{\cdot}19 : -12{\cdot}00.$$

The solution now proceeds on conventional lines, and is summarised briefly below.

No Sway.—With all the joints clamped, application of the vertical load of 5 tons produces fixed end moments at B and C of magnitude 9·375 ton-ft. The initial moments are thus $M_{BC} = -9{\cdot}375$ ton-ft., $M_{CB} = +9{\cdot}375$ ton-ft., and distribution in the normal way leads to the set of bending moments M_0 given in the first row of Table II.

Sway I.—The initial values of the moments M_{AB}, M_{BA}, M_{DE} and M_{ED} are each chosen arbitrarily to be −10 ton-ft., and distribution in the usual way leads to the set of bending moments M_1 in the second row of the table.

Sway II.—The initial values of the moments involved in the sway movement are chosen as follows:—

$$M_{BC} = M_{CB} = -6{\cdot}19 \text{ ton-ft.};$$

$$M_{CD} = M_{DC} = +6{\cdot}19 \text{ ton-ft.};$$

$$M_{DE} = M_{ED} = -12{\cdot}00 \text{ ton-ft.}$$

The bending moments M_2 obtained after distribution are given in the third row of the table.

The summations Σ_1 and Σ_2 in respect of the three sets of moments M_0, M_1 and M_2 are given in the last two columns of the table. From the values of these summations it follows that the

TABLE II

	AB	BA	BC	CB	CD	DC	DE	ED	Σ_1	Σ_2
M_0	+3·85	+7·70	−7·70	+5·58	−5·58	−1·91	+1·91	+0·95	−14·41	−8·80
M_1 ..	−6·59	−3·17	+3·17	0	0	+3·17	−3·17	−6·59	+19·52	+11·71
M_2	+2·11	+4·21	−4·21	−6·15	+6·15	+8·02	−8·02	−10·01	−11·71	+46·16
M	+4·82	+11·24	−11·24	−0·34	+0·34	+6·32	−6·32	−9·74	0	+37·51

equations for the determination of the factors λ_1 and λ_2 by which the sway distributions need to be multiplied are

$$-14{\cdot}41 + 19{\cdot}52\,\lambda_1 + 11{\cdot}71\,\lambda_2 = 0$$

$$-8{\cdot}80 + 11{\cdot}71\,\lambda_1 + 46{\cdot}16\,\lambda_2 = 37{\cdot}5,$$

and their solution gives $\lambda_1 = 0{\cdot}161$ and $\lambda_2 = 0{\cdot}962$.

The actual moment M at any section, calculated as $M_0 + \lambda_1 M_1 + \lambda_2 M_2$, is given in the last row of the table.

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BRITISH SYNTHETIC RUBBER

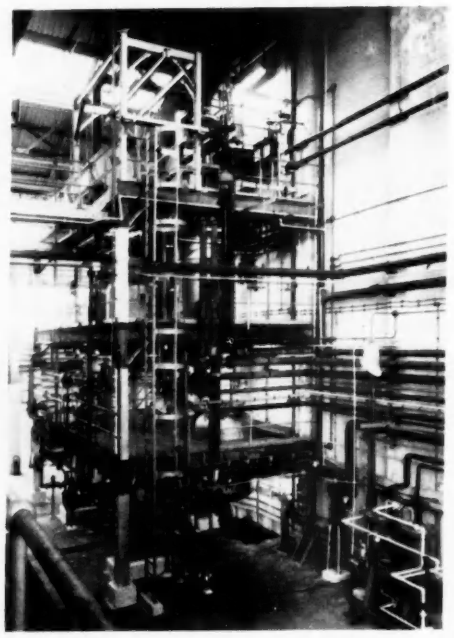
First Plant Established at Birmingham

A new plant recently commissioned by the Dunlop Rubber Company, Limited, at Fort Dunlop, Birmingham, 24, is the first to produce synthetic rubber on an appreciable scale in this country. Designed for an output of 1,500 tons a year, the plant will take its raw materials, the monomers butadiene and styrene, from the British oil-refining industry, and will manufacture synthetic rubber of the general purpose type. It has been designed to be flexible in operation, and to be suitable for producing new synthetic rubbers as they are developed by the company's Central Research Division.

The plant, which is on a 12 acre site adjacent to the company's existing works at Fort Dunlop, has storage capacity for 2,000 gallons of styrene and 6,000 gallons of butadiene. Both these materials as received and stored contain polymerisation inhibitors. The tank farm is isolated, a hundred yards from the main plant buildings, to meet the regulations for storage of inflammable materials. Pre-treatment equipment is located between the tanks and the main plant, and the monomers are first pumped to this point, for treatment by alkali or distillation to remove the inhibitors.

Emulsification of the monomers in a dilute soap solution follows, special materials such as catalysts and modifiers are added, and polymerisation takes place under closely-controlled conditions in special reactors. The solution make-up area, where soap solutions and catalysts are prepared, adjoins the reactors. Liquids are pumped in metered quantities into the reactor vessels, which are of steel, glass lined, and water jacketed. Mechanical stirrers operate continuously during polymerisation, which is carried out at a temperature that can be adjusted to suit requirements. Low temperatures can be provided when necessary by circulating cooled brine, refrigeration equipment being incorporated in the plant.

When the required conversion has been effected the reaction is stopped, and unreacted monomers are stripped off, butadiene by flashing and styrene by stripping in low-pressure steam equipment designed and patented by Dunlop. Finished latex passes to storage tanks and thence to the coagulation unit, where the liquid latex is coagulated into rubber crumb by the addition of salt and sulphuric acid.



Some idea of the scale of the Dunlop Rubber Company's new synthetic rubber plant, which has a designed output of 1,500 tons a year, is seen from this view of the styrene-recovery unit.

Coagulated crumb is freed from surplus serum on a vibrating screen and washed and filtered in a series of operations, during which a squeeze-roll conveyor converts it into sheet. This is then shredded back to crumb and dried in a three-pass steam-heated drier. A weighing machine and baling press enable bales of synthetic rubber of pre-determined weight to be made, and the bales, after dusting with soapstone, are wrapped in polythene-lined paper bags and sewn up ready for dispatch.

AUSTRALIAN BAUXITE AND ALUMINIUM'S FUTURE

The drive to develop commercial deposits of bauxite goes on. It has been announced that a new company to be called Commonwealth Aluminium Corporation has been registered in Queensland by Consolidated Zinc Proprietary Limited to work the promising bauxite deposits in Cape York Peninsula. The British Aluminium Company are to be associated with the Aluminium Corporation which, for some time, will be a planning and development organisation. An announcement was made in August, 1956, by Consolidated Zinc that large deposits of the ore had been discovered and, to date, several hundred million tons have been proved suitable for manufacture into alumina.

British Aluminium has been interested in the development of bauxite deposits in the South Pacific area for some time and the decision made some years ago to proceed with the Volta River scheme in the Gold Coast instead of developing the Borneo deposits was taken only after a good deal of discussion. The decision in favour of the Gold Coast was by no means an obvious choice between the alternatives. Since then British Aluminium has been engaged in surveying the hydro-electric power resources of Papua and in carrying out complementary investigations in Australia.

The possibility of further large tonnages of alumina to be made into aluminium ingots raises once again the question of the long-term competitive power of aluminium. As was pointed out in the first of the Engineering Outlook series, on page 9, last week, the probability that the United States may become a net exporter of aluminium ingots when the current expansion programme reaches its final stages cannot be ignored. Before long aluminium may be faced with the need to sell itself on an increasing scale, for it cannot be assumed that the present rate of expansion in the demand for aluminium in the fields developed so far will be high enough to absorb rising output. To judge from its record over the last 10 years, the aluminium industry is well equipped to face up to such a challenge.

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CHEMICALS IN EUROPE

Prospects for the Industry

Expansion in the chemical industry of Western Europe continued at a high rate during 1955 and the first half of 1956, and is expected to go on in 1957 though more slowly than hitherto. The industry's future is likely to depend mainly on its ability to recruit enough managerial and highly qualified scientific and technical staff. In most countries, particularly in Britain and Western Germany, who between them account for over half of the employment, the industry's expansion plans are threatened by this shortage. Another important factor is the provision of adequate capital for new plant and modernisation schemes. Perhaps because of this the chemical industry of Western Europe continues to lag behind that of the United States in the rate of expansion; during the first half of 1956 chemical production in the United States rose by 10 per cent. compared with the same period of 1955, whereas the corresponding figure for Western Europe was only 6 per cent. Both in America and Europe the chemical industry has been, ever since 1956, a "growth" industry, the index of production being consistently and substantially higher than that of the total industrial production. But the gap is narrowing—in 1955 the chemical industry in Western Europe expanded at a rate about 35 per cent. greater than all industry; in the first half of 1956 this figure had fallen to 20 per cent.

This information is given in the third report of the Chemical Products Committee of the Organisation for European Economic Co-operation (O.E.E.C.), *The Chemical Industry in Europe—October* 1956. This is an excellent review of the industry, which includes an analysis of the situation in each of the 13 constituent countries of Western Europe and in the United States. There are eight main "sector studies" which include plastic materials, paints and varnishes, soaps and detergents and petroleum chemicals. The last-named is the most dynamic of all the sectors of the industry. The British petroleum chemical industry is planning to double its size in terms of investment over the next two years. The West German industry is planning to do likewise. The largest expansion, however, is to take place in France where the industry expects to spend 130 million dollars on plants scheduled to come into operation by the end of 1958, thus increasing the size of the industry between three and four times. The investments planned over this period in Britain are 127 million dollars and 90 million dollars in Western Germany. Synthetic rubber will play a prominent part in this expansion in all leading countries.

Taken overall, the plans of this well documented industry suggest a very large demand for chemical plant over the next two years, probably tapering off towards the middle of 1958 but remaining healthy. Whether the expansion plans are adequate will depend on the extent to which Western European countries succeed in raising living standards in the coming year.

Book Reviews

CHANGES OF STATE AND COMPOSITION

Chemical Engineering Practice. Vol. I: General; Vol. II: Solid State. Edited by HERBERT W. CREMER and TREFOR DAVIES. *Butterworths Scientific Publications, 88 Kingsway, London, W.C.2.* (95*s.* each volume.)

For many years the question " What is a chemical engineer? " has caused some embarrassment to the profession and amusement to others, and in spite of the efforts of the Institution of Chemical Engineers, each year it appears to become more difficult to give an explicit answer to the question " What is a chemical engineer? "

Certainly the official definition, " A professional man experienced in the design, construction and operation of plant and works in which matter undergoes a change of state and composition," does not satisfy the growing scientific wing of the profession, which perhaps thinks of " chemical engineer " as a qualification rather than as a definition of a function. At a recent O.E.E.C. conference on the training and functions of the chemical engineer, one French delegate went so far as to say: " The new discipline is a cross roads not only for technologists but for economists; it interprets, codifies, translates. It is concerned with everything without becoming superficial and deals with details without specialising." These are indeed ambitious claims, but they are supported by the extreme protagonists of chemical engineering, many of whom are in our universities, and who believe that this broadly-based discipline of applied science gives to a student a judgment and facility for the art of technical co-ordination that no other field of study can.

In relation to this view, it is appropriate to consider what each man working for a university degree in chemical engineering acquires in the way of preparation. Besides studying basic chemistry, engineering science and mathematics, he is trained in the application of these sciences to industrial processes. He is taught to think of a manufacturing process as a balanced system complete with raw material, energy, manpower, transportation and marketing services. He is told that a process must never be considered out of its economic context, nor out of the context of human relations.

The task of training these paragons, if they really exist, is immense and obviously cannot be completed in the three years of a university honours-degree course. There was an obvious need for a series of books which would attempt to cover the wide field of activity claimed by chemical engineers, and would satisfy the *avant garde* in the philosophy of the subject. This seems to be the purpose of the new series " Chemical Engineering Practice," which is being produced in about 12 volumes under the general editorship of Mr. H. W. Cremer and Mr. Trefor Davies, the first two volumes of which have recently appeared.

The editors, in their preface, hasten to explain that these books will be much more than handbooks of ready-made made rules. " Those who have been responsible for the form of the present publication," they write, " were very sensible of the fact that under the stress and speed of modern industrial developments the chemical engineer is increasingly at a loss to find ready-made answers to his problems. There still remains a great gulf fixed between theory and practice, a space which of necessity he must on occasion endeavour to fill. Consequently, it was thought appropriate to include what some may regard as a disproportionate amount of *theory* in a treatise in the title of which they are likely to regard *practice* as the objective word."

The overall plan in the production of the work has been to consider processes and operations on the basis of the underlying physico-chemical principles involved. This, it was thought, would offer a more logical means of progressing from theory through plant design and construction to actual process operation on the industrial scale. To cover the immense field the services have been secured of leading chemical engineers in the United Kingdom and the Continent, both from the universities and from industry. To have done this is itself a remarkable achievement. The scholarship of the readers is another factor which has been faced with courage; it is assumed that readers have attained a first degree standard in the pure or applied physical sciences and that they are familiar with mathematical methods.

The first volume is concerned in the main with three important aspects of the chemical engineer's work; the preparation of material and energy balances on reacting systems, the design and operation of pilot plants and semi-commercial units and the interpretation of results obtained from their operation, and the preparation of flow diagrams for full-scale production. There are preliminary chapters on the concept of chemical engineering, and a chapter on units, dimensions and calculations which it would have been appropriate to put at the beginning rather than at the end of the book. The second volume has the somewhat curious title " The Solid State." The concept of matter in the solid state is effectively discussed, and there are chapters concerned with the structure of metallic alloys, fatigue and creep in metals and the mechanical properties of plastics. The second half of Volume II deals with corrosion and all aspects of porous structures from powder metallurgy to the flow through porous beds with reference to particular examples such as combustion in solid-fuel beds and the treatment of water and sewage. There is a final chapter on transpiration cooling.

The treatment throughout is modern and probably achieves what the general editors hoped. As a whole, it is unlikely to be recommended as a university text-book, but students will undoubtedly be told on occasion to consult it as a supplementation to their lectures, and the series should certainly be available in all colleges for this purpose. For the practising engineer, it offers something more than a handbook, it may, by the inclusion of underlying theory and its development, suggest the means of solution of new problems. The work as a whole is an enormous undertaking, but the editors can congratulate themselves that they have made a good start.

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NEW BOOKS

Some of the books noticed here are selected for extended review in ENGINEERING.

Aeronautical History in Pictures. *Science Museum, South Kensington, London, S.W.7,* and *H.M. Stationery Office, Kingsway, London, W.C.2.* (2*s.*)

The booklet recalls briefly a selection of some historic events, machines and personalities in the development of flight, from the first balloon voyage in 1783, through the pioneering model and gliding experiments to the Wright brothers' early European aircraft, aircraft of the first World War, the inter-war period, aircraft of the second World War, early examples of jet propulsion, post-war civil aircraft, rotating wing aircraft and post-war British military aircraft.

Maintenance of High-Speed Diesel Engines. A practical Handbook for Diesel Engine Fleet Owners, Maintenance Engineers, Operators, Drivers and Mechanics. By ARTHUR W. JUDGE. Fourth edition revised. *Chapman and Hall, Limited, 37 Essex-street, London, W.C.2.* (56*s.*)

This is the fourth edition of a work which first appeared in 1936, and has now been largely re-written, with a considerable number of new illustrations added. The chapter sequence has also been rearranged and two new chapters, of which one is on engine testing after overhaul, have been included. The book is mainly concerned with the automobile type of compression ignition engine, but a great deal of the information is also applicable to many industrial types. The treatment is from a practical point of view.

Calenders for Rubber Processing. By H. WILLSHAW. *The Institution of the Rubber Industry, 4 Kensington Palace-gardens, London, W.8.* (25*s.*)

The author describes the uses and developments of calenders in the rubber industry from the user's point of view. The book covers calender design, types of calenders, driving gear, speed control systems, safety braking systems, feeds and thickness gauging, roll contours and uses in production. A bibliography and a glossary are included.

Cams: Design, Dynamics and Accuracy. By HAROLD A. ROTHBART. *John Wiley and Sons, Incorporated, 440 Fourth-avenue, New York 16, N.Y., U.S.A.* (9.50 dols.); and *Chapman and Hall, Limited, 37 Essex-street, London, W.C.2.* (76*s.*)

The book is written primarily for the designer concerned with creating a mathematical function, motion, mechanism, machine or mechanical computer. The author considers kinematics, i.e., the relative motions of constrained, rigid members; dynamics, and machine design. Mathematical treatment is kept to a minimum, but for the understanding of the chapters on " Polydyne Cams " and " The Dynamics of High-Speed Cam Systems," the reader requires an understanding of basic vibration theory. The book includes a discussion of profile accuracy and errors.

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TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Chemical Pumps. RHODES, BRYDON AND YOUAT, LTD., Waterloo Engineering Works, Gorsey Mount-street, Stockport. " Mopumps " for chemical process work. Horizontal single-stage models with inlet bores of 2, 3, 4 or 6 in. diameter. Up to 200 ft. total head at 2,900 r.p.m. Particulars and performance curves given in Publication 1460 A.

Heavy-Oil Purification. SHARPLES CENTRIFUGES LTD., Tower House, Woodchester, Stroud, Gloucestershire. " One-pass " centrifugal purifier/clarifier for heavy fuel oils up to 3,500 secs. Redwood No. 1 at 100 deg. F. Leaflet.

Air Compressor. CLIMAX ROCK DRILL AND ENGINEERING WORKS LTD., Redruth, Cornwall. D.30A transportable two-tool compressor, free air delivery 120 cub. ft. per min. at 100 lb. per sq. in. Specification leaflet.

Rock Drills. CLIMAX ROCK DRILL AND ENGINEERING WORKS LTD., Redruth, Cornwall. Twin-drill trench rig for drilling in trenches from very narrow up to 6 ft. wide. Leaflet giving specification, description, and operating data.

Rubber Sealing Strip. HOWARD CLAYTON-WRIGHT LTD., Wellesbourne, Warwickshire. Stickastrip adhesive sponge rubber sealing strip, affixed by moistening with spirit and pressing on to wood, glass, metal, etc. Illustrated leaflet.

Adjustable Support Clips. HOWARD CLAYTON-WRIGHT LTD., Wellesbourne. Nylastic adjustable self-locking clips for cable runs, etc. Made from hard Nylon 66. Specification and technical data leaflet.

Stainless Steel Pipe Fittings. TALBOT STEAD TUBE CO. LTD., Green-lane, Walsall. Metior stainless steel unions, blank caps, plug cocks, T-fittings, bends, reducing bends and liners. Illustrated leaflet.

Trucks and Ladders. BARDSLEYS-COLCHESTER LTD., 196 Bergholt-road, Colchester. Sack-trucks, trailer trucks and wood or aluminium ladders. Various leaflets.

Electrical Accessories. M.K. ELECTRIC LTD., Wakefield-street, London, N.18. Electrical switches, plugs and sockets for domestic light and power circuits. Illustrated catalogue.

Fire Alarm Systems. CARTER & CO. (NELSON) LTD., Nelson, Lancashire. Syrens and break-glass fire alarm contacts, relays and indicators. Descriptive leaflet and price list.

Lighting. STRONG ELECTRIC CORPORATION (GREAT BRITAIN) LTD., Whyteleafe, Surrey. Fluorescent lighting fittings. Illustrated catalogue.

MACHINE FOR DETERMINING THE VIBRATION OF PRECISION BALL BEARINGS*

By H. L. Wunsch, M.ENG., A.M.I.MECH.E.

In view of the increasing use of small precision ball bearings, running at high speeds, it was thought desirable to develop a machine for testing these bearings for both vibration and frictional torque. In order to simplify the design of such a machine, it was decided to carry out the two tests separately. Accordingly, a machine has been developed for continuously recording the frictional torque in precision ball bearings running at high speeds and under various loads, and this has been fully described in a previous report.† Further work has now been carried out on the development of a machine for determining vibration in ball bearings, and the following report describes the construction and operation of this machine. It had originally been intended to measure airborne noise rather than vibration, but it was felt that the difficulties in doing this would be excessive in view of the presence of various sources of external noise. It was therefore decided that measurement of vibration, while presenting fewer difficulties, would still provide the required data concerning the ball bearing.

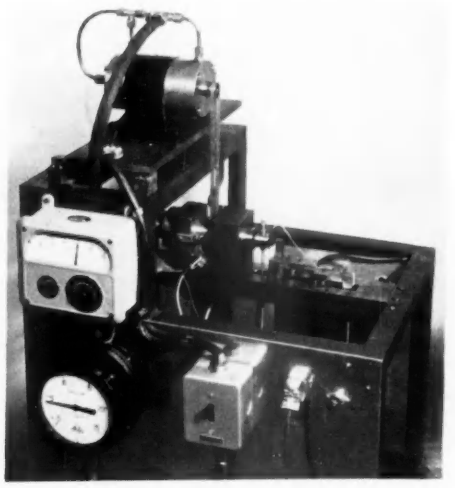

Fig. 2 General view of equipment.

LIGHT HIGH-SPEED DRIVE FREE FROM VIBRATION

APPLYING TEST LOADS AXIALLY AND RADIALLY

The machine described below is capable of running ball bearings of 5 or 10 mm. bore at speeds up to 60,000 r.p.m. and under separate or combined axial and radial loads of up to 20 lb. The vibration of the ball bearing is measured in a radial direction and an electrical output signal proportional to this vibration is provided. Facilities for accurate measurement of speed are also available.

The driving unit for this machine is a high-frequency motor mounted on air-lubricated bearings of similar design to that used in the friction testing machine and is fully described in the earlier report. As before, the motor, which is slightly smaller than the previous one, was run for several hours at 60,000 r.p.m. and was found to be perfectly satisfactory.

Air Bearing.—Utilising the experience gained in the development of the friction testing machine, the high-speed air bearing has been modified for the purposes of this machine. In order to satisfy the specification of 20 lb. axial and radial load at the bearing under test, the size of the air bearings has been increased. Since this load is applied asymmetrically, it was decided to make the bearing nearest to the applied load larger than the other one, and in the present design the bearings are in fact 1½ in. diameter by 2 in. and 1½ in. by 1 in., respectively. The smaller bearing is supplied by one row of three admission holes of 0·025 in. diameter, eqully spaced. The larger bearing has two rows of admission holes ½ in. from each end. Each row contains three equally-spaced holes of 0·025 in. diameter with an additional fourth hole of 0·010 in. diameter at the bottom of the bearing. The bearing is made in this way because the design of the machine ensures that it will always be loaded in a downward direction. The radial clearance in the bearing is of the order of 0·001 in. With this arrangement of air admission holes and clearance, it was found that a load of up to 25 lb. could be applied to the ball bearing under test.

An additional feature of this new design is that the pipework of the previous air bearing has been replaced by internal air passages, so that only one air supply point is sufficient for all the radial bearings. This is clearly shown in both the sectional drawing, Fig. 1, and the view of the machine, Fig. 2. The thrust bearing used in the machine is of the same design as on the friction test rig, that is with conical escapement and one central admission orifice of 0·030 in. diameter. This also appears in Figs. 1 and 2.

As in the previous machine, the drive is transmitted from the high-speed motor to the air-bearing shaft by means of a linseed oil-impregnated tussore silk belt. The motor is mounted on a platform which can be tilted about a hinge at one end, so that the belt tension can be readily adjusted.

Ball-Bearing Housing.—The design of the ball-bearing housing in this machine is of very simple form, as can be seen from the sectional view, Fig. 3. The outer race of the ball bearing is a sliding fit in the housing and bears axially against a square shoulder. It is held in position by an axial clamp. In view of the simplicity of this design, it was decided not to use adaptors for different sizes of ball bearings, but to provide separate housings. It was considered permissible to apply the required axial and radial loads directly to the ball-bearing housing. The radial load is carried directly on a weight carrier attached to the bottom of the housing. The axial load is applied by direct loading through a system of levers, finishing with a ball-ended contact on the centre line of the ball-bearing housing. A rubber pad is placed between the end of the housing and the ball in order to allow the ball-bearing outer race, and hence the housing, to vibrate freely. This is shown in Fig. 4.

Speed Measurement.—The speed of the main air bearing shaft is measured photo-electrically. Three equally-spaced holes, ⅛ in. in diameter, are drilled diametrically through the shaft, thus giving effectively six passages per revolution. Light from a small light source is arranged to shine through these holes on to a Type 90A germanium photo-cell placed on the other side of the shaft; this results in six electrical impulses given out by the photo-cell per revolution and these, after being amplified, are applied to a suitable counting instrument of either the frequency monitor or the frequency meter class. Thus, a direct reading of speed can be obtained. The general arrangement of the speed-measuring equipment is illustrated in Fig. 5.

* Communication from the Mechanical Engineering Research Laboratory, East Kilbride, Glasgow.

† ENGINEERING, vol. 178, page 695, 1954.

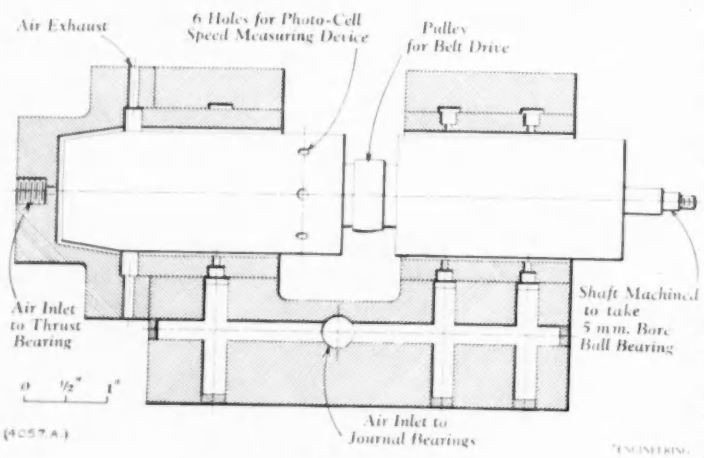

Fig. 1 Design of air bearings.

MEASURING HIGH-FREQUENCY VIBRATIONS

After due consideration of the conditions under which the vibration measurements had to be carried out, it was decided to use a piezo-electric pick-up of the barium-titanate type. This consists of a small disc of barium titanate held between a metal base and a comparatively large metal mass. If the base is subjected to forced vibrations, the disc undergoes a cycle of alternating stresses, since the inertia of the metal mass tends to keep it stationary in space.

The alternating stress that is in the disc causes a voltage to be generated between the top and bottom face of the disc, and this voltage is proportional to the force applied and hence to the acceleration component of the vibration. The advantage of this type of pick-up is its comparatively high output for quite a small size, and this latter fact makes it especially suitable for this application.

Two forms of construction were tried and are shown in Fig. 6; both proved to be equally satisfactory. In the first, the base, the disc and the metal mass were held together by means of Araldite, which is a hot-setting resinous adhesive. In the second type the disc and metal mass had a central hole and were bolted together by means of a stud machined integral with the base. In this case, the mass had, of course, to be insulated from the stud. In both forms, the electrical connections were made by means of two wires soldered to the mass and the base respectively. The bottom of the base was finished in the form of a 4 BA screw which could be directly screwed into the ball-bearing housing; the top of this housing was machined flat and a lead washer placed between it and the pick-up to obtain satisfactory mechanical contact.

This type of pick-up requires polarisation which is carried out as follows. The pick-up is heated

in a suitable oven, and preferably in an oil bath, to about 110 deg. C. At this temperature a d.c. potential of about 30 volts per 0·001 in. (in this case 4 kV) is applied across the barium titanate, the mass being positive and the base negative. The temperature is then raised to 135 to 140 deg. C. and held there for half an hour, after which the pick-up is allowed to cool down slowly. The d.c. potential is not removed until the temperature has fallen to about 70 deg. C. In the case of the bolted type of pick-up it was necessary to carry out the polarisation on the disc by itself, since the high voltage would cause electrical breakdown between the mass and the central stud. The disc was assembled in the usual way after polarisation with its positive side to the mass.

In order to obtain the frequency response and the sensitivity of these pick-ups, it was decided to have one calibrated and to use this as a standard, with which any other pick-ups could be compared. This work was carried out by the Admiralty Research Laboratory who used a reciprocity technique to obtain the pick-up response in the range 50 to 10,000 cycles per sec. Their results showed that sensitivity was flat to about 1 dB up to 5,000 cycles per sec., and that from 5,000 to 10,000 cycles per sec. there were one or two small resonances of less than 5 dB, which can probably be ascribed to the method of mounting. Several pick-ups were later compared with this standard by mounting both on a vibration generator and obtaining the relative outputs at various frequencies up to 10 kilocycles per sec. It was found that all the pick-ups tested in this way, of both types of spectrum analysis, but to carry this out at each speed and loading condition on a large number of ball bearings would be very tedious and would take far too long. A possible compromise is to carry out an octave analysis, that is, dividing the frequency range into suitable octave bands and evaluating the r.m.s. amplitudes of each band. This can be done by means of an octave filter. If this division is thought to be too coarse, a one-third octave analysis is also possible. In addition, there are instruments available commercially which carry out a one-third octave analysis automatically, presenting the results in the form of a paper chart.

As can be seen, there is a comparatively large number of methods of evaluating the results of a vibration test, and the one to be used must be decided on the merits of each particular

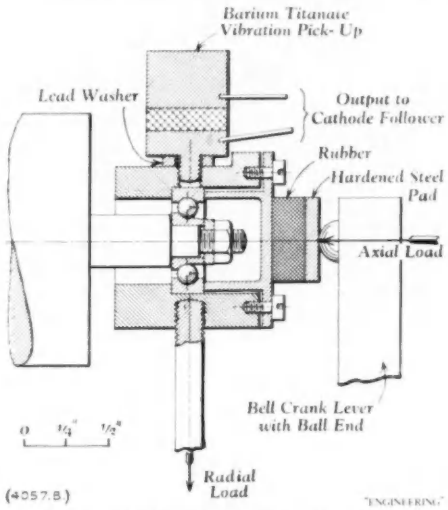

Fig. 3 Details of ball-bearing housing.

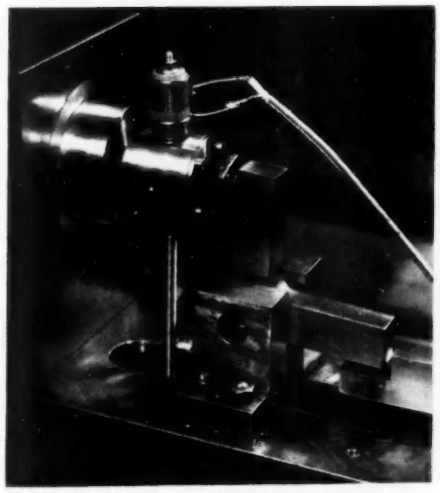

Fig. 4 Method of applying axial and radial loads.

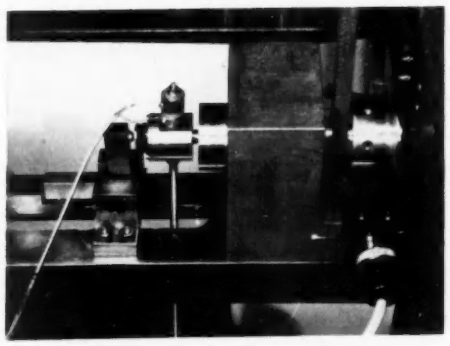

Fig. 5 Speed-measuring equipment.

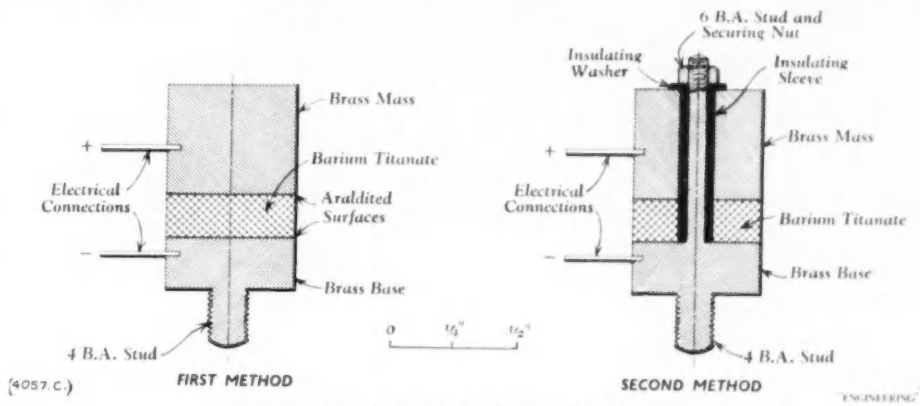

Fig. 6 Alternative methods of measuring vibrations.

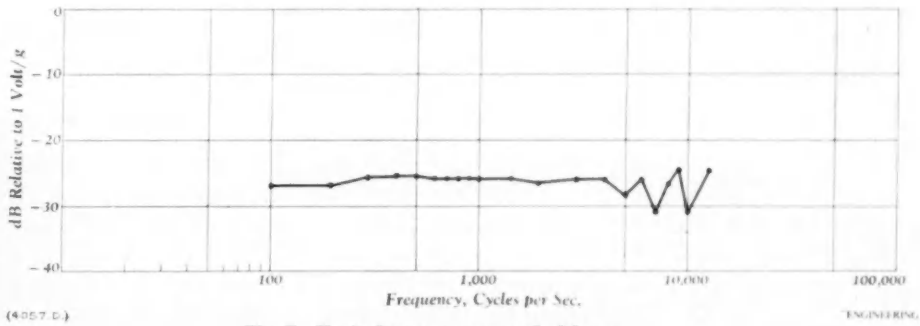

Fig. 7 Typical response curve of pick-up.

construction, had similar response curves to the standard one. A typical response curve is shown in Fig. 7.

The output from this type of vibration pick-up should be fed into a cathode follower with high input impedance, and this should be placed as close to the pick-up as convenient. In the case of this machine, the cathode follower is built into the frame and its output is taken to a suitable socket, from which it can be taken to any one of several different types of measuring instruments. This point is discussed in the next section.

Evaluation of Vibration Measurements.—The question of the most suitable methods of interpreting the results obtained from this machine is still under consideration; briefly the possibilities are as follows. The output taken directly from the pick-up gives a measure of the acceleration component of the vibration. Alternatively, if this is not considered to be suitable, a single or double integrating circuit can be used to obtain the velocity or displacement components. The choice depends largely on what effect of vibration is under consideration, that is, wear, airborne noise, etc.

Again, having obtained an electrical signal, whether proportional to acceleration, velocity or displacement, several methods of evaluation can be used. The simplest is to take the r.m.s. value of the total output directly as a measure of vibration, but this will, in general, not give all the required information. The most informative method is to subject the signal to a complete case. Further work in progress at the moment is intended to obtain typical results by the various methods and to compare their usefulness in judging the quality of a particular ball bearing.

Acknowledgments.—The author wishes to express his thanks to the Admiralty Research Laboratory, Teddington, for their co-operation in the design and calibration of vibration pick-ups. The work described was carried out under Admiralty contract and forms part of the research programme of the Mechanical Engineering Research Board of the Department of Scientific and Industrial Research. This article is published by permission of the Director of Mechanical Engineering Research.

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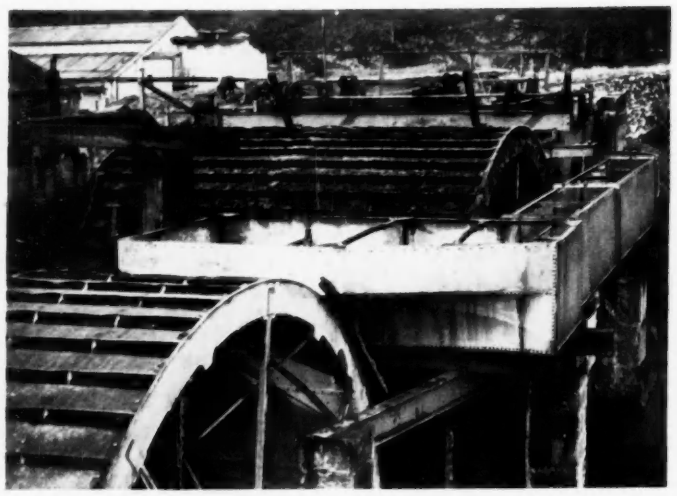
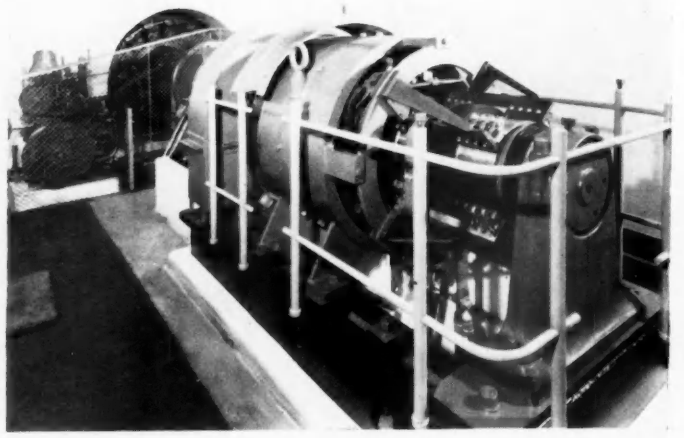
VEHICLE GEARBOX

A new commercial-vehicle gearbox has been introduced by the David Brown Automobile Gearbox Division, Park Works, Huddersfield, to be known as the S.550 model. It has 5 forward speeds and a reverse, and all gears are in constant mesh. With the exception of the first, all the forward speeds are synchronised, the synchromesh mechanism used being of the Porsche type, which has enabled the size of the components to be reduced and gives a compact box. The designed maximum input torque is 300 lb.-ft. and the box is available with a choice of two ranges of ratio.



Two old water wheels (one dates back to 1827, when it was installed for spinning cotton) which have recently been replaced at a Bakewell works.



100 kW Gilkes-English Electric hydraulic turbo-generator which takes the place of the water wheels.

TURBINE REPLACES TWO OLD WATER WHEELS

Two of the country's most important industries —textiles and electrical manufacture—have been linked over a period of nearly 200 years in works at Bakewell, Derbyshire, which are now occupied by the D.P. Battery Company, Limited. These works also form an example of the earliest and most modern application of water power to production, being first constructed by Arkwright in 1777 for the spinning of cotton and then taken over with surrounding property by the D.P. Battery Company in 1898 for the manufacture of electric storage batteries. A water-wheel was first introduced for the supply of power in 1827 and a second similar unit was added in 1852. These wheels, shown in the photograph above (by courtesy of *The Derbyshire Times*), have been used until last year to drive a 66 kV generator, but after breakdown of the older one have now been replaced by a turbine.

Before describing the new plant it may be mentioned that the older of the two wheels was built by Hawes and Wren of Manchester and was 25 ft. in diameter by 18 ft. wide. A series of 70 buckets was arranged round the circumference of the wheel, each being capable of holding about half a ton of water from which the power was derived. Under normal working conditions the total weight of the water in the buckets was about 10¾ tons. Obviously the wheel would have had to be a very massive structure if power had been transmitted through the spokes and axle, as would have been necessary with one of the undershot type. To avoid this a series of teeth were therefore arranged round the inner circumference of the wheel and engaged with a pinion at a point just below that at which water entered the buckets. Thus the weight of the water was applied more or less directly to a pinion wheel which was nearly 5 ft. in diameter by 14½ in. wide and operated the shafting in the mill.

The smaller wheel, which was 21 ft. in diameter by 7 ft. wide, was of similar construction and was built by Kirkland and Son, of Mansfield.

These wheels fulfilled their purpose until, as has been said, breakdown of the larger of the two occurred. This was caused by the fracture of one of the teeth, which became jammed against the pinion. As a result many more teeth were stripped from the wheel and a number of the cast-iron segments were broken. All the teeth on the pinion wheel were also torn away, the frame supporting the buckets was cracked and a 10 ft. diameter driving wheel in the works was displaced and damaged. Repair being impossible replacement was the only course which could be adopted and this was carried out with the agreement of the Town and Country Planning Authority to whom the damage was reported, the plant being considered of historical interest.

The new plant, which is also illustrated above, consists of a horizontal Francis turbine, manufactured by Gilbert Gilkes and Gordon, Limited, Kendal, and designed to develop 150 b.h.p. when running at 213 r.p.m. under a head of 21·5 ft. It therefore has an output 50 per cent. greater than the old plant although using the same head. The flow of water at this rating is 74·5 cub. ft. per sec. and the speed of the turbine is controlled by an oil-pressure governor. Water is admitted through two sluice gates which are fitted with worm operated rack and pinion lifting mechanism and flows through a steel-bar strainer with an area of 120 sq. ft.

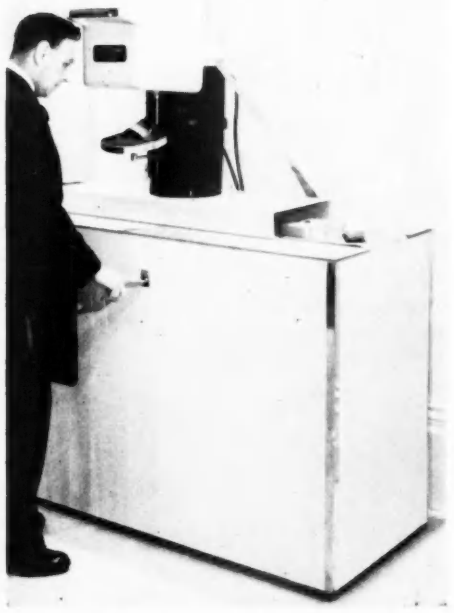
The turbine is connected through a David Brown speed-increasing gear unit to a 100 kW English Electric protected type generator, which supplies direct current at 100 volts when running at 750 r.p.m. The output from this generator is controlled from a cubicle type generator panel which is also of English Electric manufacture and supplements the power produced by steam turbine and Diesel driven sets. The water-driven generator runs steadily in parallel with both these sets without the necessity for automatic voltage regulators, although three different types of governor gear are used on the different prime movers. The control panel incorporates an air-break circuit-breaker, fitted with arcing chambers, thus obviating the use of blow-out coils and providing the maximum breaking capacity.

ECONOMIC USE OF X-RAYS

Radiographic techniques are finding increasing application in industry. However, the methods employed are not always economical. For high power equipment must be used for each specimen, whereas many faults are sufficiently large to be detectable by cheaper equipment of much lower power. It is not practicable to radiograph the whole batch initially, at a low power, on account of the increased photographic work entailed, and the solution would seem to lie in the use of a fluorescent screen for the visual inspection of the X-ray image. A normal fluorescent screen has the disadvantage that it too needs high power X-rays to produce a clear image, but the disadvantage may be overcome by the use of image magnification.

The Marconi X-ray Image Amplifier, recently introduced by Marconi Instruments Limited, St. Albans, Herts, uses an electronic-optical system which entails the substitution of an electronic image-converter tube for the normal fluorescent screen. This tube has its own fluorescent surface upon which the X-rays passing through the object will impinge. The resulting fluorescence excites a photo-electric plate, causing the emission of electrons which are focussed and accelerated by a system of electrodes. The final image, increased in brilliance by the combined effects of acceleration and concentration, is produced on a second screen 1 in. in diameter. The optical system projects this image, natural size, in a mirror.

The image amplifier is used to determine those members of a batch that can be rejected without the need for radiography, and then radiograph the remainder in the usual way. A saving of time and film is achieved while no component is passed into service unless radiographed.



X-rays originate in the lower half of the equipment and pass through the object under scrutiny into the image-converter tube in the black casing.

HIGH-SPEED INFORMATION ROOM AT SCOTLAND YARD

One of the many tasks that faces the Metropolitan Police is that of employing a large fleet of vehicles in as efficient a manner as possible. To achieve this end, a high degree of organisation is necessary, that may only be brought about by the introduction of a central information room in radio contact with each vehicle. It is customary to refer to this room as a " nerve centre " and however hackneyed the epithet may be it is certainly appropriate. For in many ways the type of activity shown by the information room of Scotland Yard resembles that of the brain. Receptor organs—telephone and burglar alarm systems—feed data into the room. The data are analysed in the light of experience and circumstances, decisions are taken, and important facts are committed to memory. The implementation of decisions is attempted by sending orders to the appropriate effector organs—vehicles—and the subsequent events are monitored and influenced by the individual vehicle-room feedback loop.

As far as the engineer is concerned the success with which the system operates depends on the efficiency of the communication channels and of the information room; the behaviour of the other components, though no less important, is beyond his control. The communication channels used by Scotland Yard are working at as close to maximum efficiency as may be expected under present conditions. The information room, on the other hand, was recently starting to show signs of inefficiency. The data handling capacity of the old room, last modified in 1946, was becoming inadequate to cope with the greatly extended use of the 999 emergency system.

The new information room, which was opened early this month, was designed by the Engineering Department of the Receiver's Office, with the experience obtained in the operation of the old room providing a most useful guide. The previous information room suffered acutely from serious physical overcrowding: inadequacy of space for all the staff required in the busy parts of the day and night, lack of adequate ventilation, and excessive noise. There were no facilities for visitors, who often were members of overseas police forces who wished to see the operation of the system at close quarters in order to follow it in detail. Furthermore, too much of the telephonist's time was taken up in walking about the room—to the table maps to select a car, to the radio operator, loggist, and telegraph office to deliver copies of a message. It was clear that it would be necessary to mechanise procedure to reduce time wasted.

It was decided that each of the telephone operators required easy access to telephone switching facilities, an indicator showing which vehicles are available at any given instant, a map showing the boundaries of the Metropolitan Police districts, a condensed street directory, conveyor belts to take messages to their appropriate destinations, and an accurate, easily visible, clock. Also since the room is in continuous operation it was essential that maintenance of furniture and equipment should be reduced to a minimum.

A full-scale partially working model was produced, and after adjustments were made the dimensions were passed to the architect's department for incorporation in the furniture design. The details of the dispatcher's position presented most difficulty, for it was necessary here to indicate the availability of all vehicles equipped with radio telephony, which include a variety of categories of cars, Thames division boats, and motor cycles. At the dispatcher's position it is necessary to know firstly whether or not the vehicle has been assigned to some particular duty, and secondly whether it is available immediately or only after some delay. The primary conditions—available or not available—are recorded electrically and

A general view of the new information room at Scotland Yard from a position just forward of the radio operator. The plug boards showing the availability of all vehicles are in the foreground. The conveyor belts travel the length of the table.

The radio operator's position. The three knobs on the right are a selective calling system; the six switches with lamps above and below are for channel selection, the lights indicating the state of the channel.

can be ascertained by each telephone operator at his own desk, but the remaining alternatives are indicated only at the fleet operator's position by a variety of coloured pegs. No such indicating system was directly available through trade channels but an estimate was obtained showing that the cost would be many thousands of pounds and the space required would exceed that available. The system in use has been designed and manufactured by the Wireless Branch of the Engineering Department of the Receiver's Office.

The layout of the room is shown in the upper illustration. The whole operational unit comprises the information room itself, the telegraph office, and the urgent communications room, which deals with radio communications to the Continent and special operations such as the control of large crowds. An enclosure has been provided within the information room for visitors. From it the work of the room may be viewed, and also—through a large plate-glass screen in the dividing wall—the work of the telegraph office. A false ceiling has been installed using a sound-absorbent acoustic plaster, and further noise reduction has been obtained by the use of soft-backed leather cloth on the larger plain surfaces of the walls. Such cloth has the additional virtue of needing no maintenance other than washing. To reduce eye-strain a soft shade of blue-green is used for the furniture and care has been taken to ensure an even distribution of light.

At each of the 14 telephone operators' positions the switching facilities provide knowledge of the availability of up to 30 vehicles per Division in 24 Divisions. Flashing indicators draw attention to any call which has not been answered within 30 seconds and in addition there is a variety of inter-communication and transfer facilities that may be applied to any call. Conveyor belts transmit the triplicate message forms from the operators to the fleet indicator positions where a check of the vehicle assignment is made and copies are passed on to the radio operators, loggist, and telegraph office. There are four radio operator positions in the information room arranged to operate the transmitting and receiving station at Forest Hill by remote control. One of these is illustrated on the left. By the operation of a switch, selected vehicles may be put in radio contact with each other through the information room's main transmitter. This is a useful service since vehicles, which have a transmitter power of 10 watts—the main transmitter is 200 watts—are not normally in radio contact with each other.

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MINIATURE RADAR RECEIVERS

The compact design of a sub-miniature radar receiver recently introduced by Elliott Brothers (London) Limited, Boreham Wood, Hertfordshire, is achieved by the fullest use of printed-circuit techniques. The receiver comprises six plug-in units, of which five are made with the components on one side of a Bakelite copper-clad laminated sheet and the etched circuit on the opposite side, connections being made by dip soldering. One of the main features of the receiver is the use of printed-circuit sheet connections at the rear of the sockets, showing that dip soldering or automatic soldering techniques may be as readily applied to these points as to the individual replaceable units. In fact throughout the receiver practically all wired joints have been eliminated. Where valve wires are to be connected, small eyelets have been inserted into the board so that if a valve change is necessary at a later date, no damage can occur to the copper foil due to careless hand soldering.

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TORQUE-ARM SPEED REDUCERS

The range of torque-arm speed reducers made by J. H. Fenner and Company, Limited, Marfleet, Hull, has now been extended by the addition of six single-reduction units, each having a fixed ratio of 5 to 1. Used in conjunction with a V-belt drive (which may give a reduction ratio up to 6 to 1) they enable standard 1,440 r.p.m. motors to be used for final outputs varying from 90 to 375 r.p.m. The largest of the six has a maximum rating of 40 h.p. The earlier range of two-stage reduction boxes gave a ratio of 15 to 1.

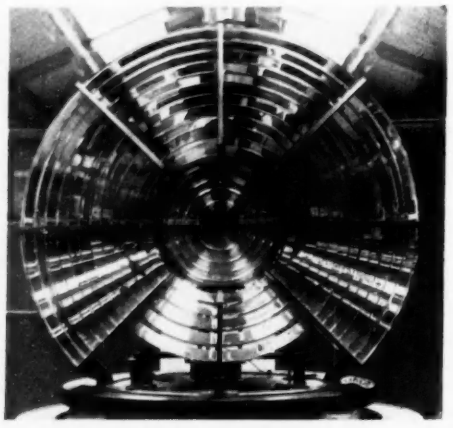

Fig. 1 One of the two optics for the Perotan lighthouse, made up of refracting and reflecting elements.

LENS SYSTEM FOR LIGHTHOUSE

An entire lighthouse assembly ordered for Perotan Island about 300 miles north-west of Bombay has recently been completed by Stone-Chance, Limited, Crawley, Sussex. The lens system is shown in Fig. 1, and also in the drawing, Fig. 2, which shows its relation to the light source. The light is timed to give a flash of 0·35 second every 10 seconds, and under normal moderately good atmospheric conditions should have a range of about 30 miles. The optic is of the third order, with a 500 mm. focus. It consists of two equal and symmetrical panels having their axes 180 deg. apart. Each panel is built up of ground and polished glass elements, these being divided into refracting and reflecting groups; the former comprise a bull's eye lens with five refracting rings and the latter twelve upper and five lower reflecting prisms as may be seen in the illustrations. The net glass areas of the refractors are 2,240 sq. cm. and the reflectors 19,700 sq. cm.

The pedestal is of the mercury float type in which the optic element on its stand rotates in an annular bath of mercury under the force of falling weights. The weights, which lie within the tower of the lighthouse, have a rise and fall of 30 ft. giving a running time of approximately 3½ hours. They can be re-wound without stopping the rotation of the optic. The centrifugal governor maintains the speed to within plus or minus 1 per cent. of the nominal speed. A battery-operated alarm bell is provided to give notification of the approach of the weights to their lower limit, and an emergency hand-turning gear is fitted to the output shaft. The light is provided by a 55 mm. Autoform mantle burner, working from petroleum vapour. This size burner has a power of 1,205 candelas, an average

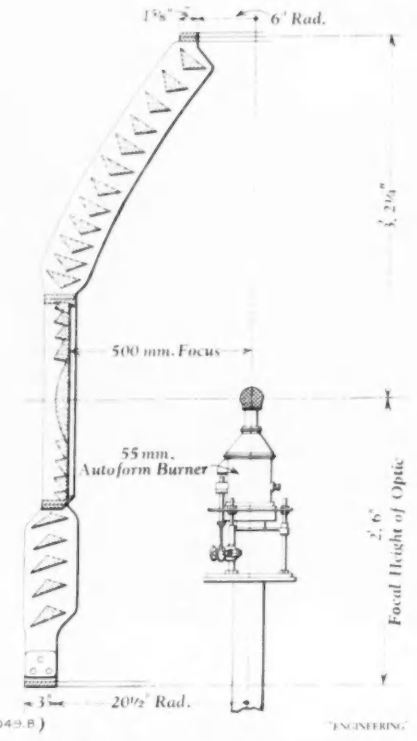

Fig. 2 The optics revolve under a system of falling weights to give a flash every 10 seconds. A petroleum-vapour burner is the light source.

brightness of 49 stilbs and a consumption of oil of 0·74 litre per hour. The optical performance of the light is that it provides a stationary beam intensity from the optic of 883,000 candelas which is reduced to 495,000 candelas when the glazing absorption and the Blondel-Rey factor have been included. The optical unit revolves in a lantern 8 ft. 9¾ in. in diameter to the glazing. This is surmounted by a conical roof of copper sheeting mounted on beams and the whole is surmounted by a ventilator and a wind vane.

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ELIMINATING DISTORTION DURING QUENCHING

Automatic Treatment for Gears

Owing to the wide variations in their sectional thicknesses and for other reasons, steel gears and similar components are liable to distortion during the normal hardening process. This, of course, is undesirable, since even a very slight departure from symmetry leads to uneven running and the overloading of a portion of the teeth in the gear.

The main object of a quenching press introduced recently by W. Ferd. Klingelnberg Söhne, the German machine-tool manufacturers, whose sole British agents are the Sykes Machine Tool Company, Limited, The Hythe, Staines, Middlesex, is to overcome these difficulties by eliminating gear distortion as part of the normal production schedule.

The D.H. 550 duplex-table quenching press is shown in the accompanying illustrations, Fig. 1 being a general view of the machine and Fig. 2, depicting the twin stations and the quenching chamber, the drop doors of which are shown open. The lower perforated "dies" of the press, on which the components to be quenched are placed, are seen in position and it will be noted that they stand clear of the machine casing. The press is capable of accommodating spur, helical and bevel gears or other components having a maximum diameter of 21⅞ in., and a maximum height of 11⅞ in.

In carrying out a cycle of operations, the component to be quenched is placed on one of the lower dies of the duplex table. By operating a lever, the table is traversed so that the die and its load are moved into the quenching chamber; the drop doors, which are controlled by hydraulic valves, are closed and an upper "die" descends and rests on the component. Pre-cooling is then effected by oil flooding through the perforated dies and, after a pre-determined period, the upper die, which hitherto has merely rested on the component, is made to clamp the work, and full cooling is achieved by a forced oil flow. A spherical pressure-transmission face between the ram of the press and the upper die ensures that the clamping load is distributed evenly. A transparent panel on the front of the cooling chamber allows the work to be observed during the quenching operation. At a moment ten seconds from the end of the total quenching time, a green lamp is illuminated as a warning to the operator to prepare the next component. When the quenching operation is completed, the control lever returns to its original position, the oil flow stops and the oil drains off, and the upper die and the doors rise.

The operating cycle is fully automatic; the times for the pre-cooling and the total treatments are set on a pair of timing dials housed in a compartment in the base of the machine. A cover, fitted to this compartment, prevents any accidental alterations of the settings. An inbuilt electric heater is fitted to bring the quenching oil rapidly up to any desired temperature and this is checked by means of a thermometer.

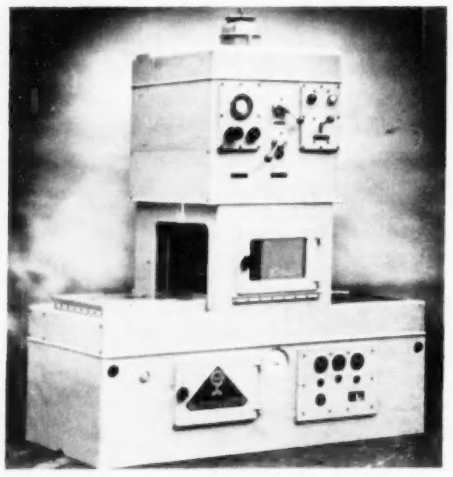

Fig. 1 (left) General view of duplex-table quenching press for eliminating distortion in spur, helical and bevel gears or other components.

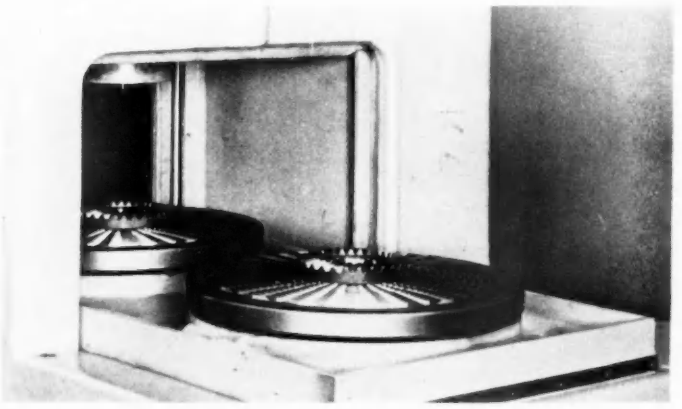

Fig. 2 (right) Quenching chamber shown open. The lower perforated "dies" of the press, on which components to be quenched are placed, are seen in position.

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PNEUMATIC TIMER

A pneumatic timer suitable for use with direct-current supplies has recently been produced by Square D Limited, 100 Aldersgate-street, London, E.C.1. It will be known as the 9050 type Q. Time settings can be varied from 0·2 sec. to 3 min., and the timer can be set so that the delay occurs before or after energisation as desired. Auxiliary switches can be fitted and operating coils for any voltage up to 250 d.c. are available.

"MESSING ABOUT IN BOATS"

AGE-OLD DELIGHTS OF SEA AND RIVER

There are those whose reaction to the word boat is one of slight loathing induced by visions of a seasick crossing of the Channel; there are others who conjure up a picture of a pleasant summer afternoon drifting quietly down the river; and there is a third category for whom the word boats induces a vision of joint pleasure and labour. It is the last group that have attended in force the third National Boat Show held at Olympia from January 1-12. That the group is a large one is proved by the fact that the size of the show is double that of the first one held in 1955. Rather more than 200 exhibitors took part with nearly as many different craft.

Outstanding among the impressions obtained from going round the stands was the enormous growth of the use of plastics, in particular resin-bonded glass fibre, as a means of construction. Something like half of the smaller boats present had hulls made of mouldings, some being finished with wooden gunwales and some with metal ribbing, but quite a few were content with the finish of the glass fibre, guarded perhaps by a strip of rubber on chafing points. Both rowing and sailing dinghys were made from these mouldings and one firm at least were showing large motor cabin-cruisers for open sea work. Glass fibre sheeting for home construction and repairers was also shown.

even in this field, and complete kits of parts are available for building rowing and sailing dinghys, punts and catamarans.

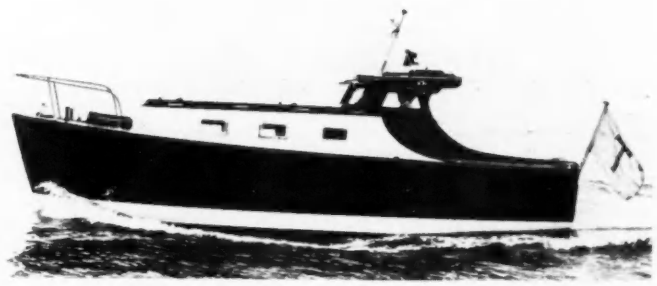
Not all boating people are content to rely on wind or muscle power, and there was a very large range of engines on display. At least 45 firms were showing engines, there being 18 makes of Diesel, 15 of outboards, and a large number of petrol and petrol/paraffin models. One firm who had previously been making conversion kits for burning paraffin in petrol engines, and had discontinued them some years ago, announced that they were going to recommence production. Quite a notable tendency among the engines was the use of self-change gears, and of remote control for the gearbox.

One of the firms manufacturing plastics-hulled boats was Boat Bureau Limited, 107 Ridgeway, London, S.W.9, who also produced a small trailer for the transport of dinghys. Apart from the actual framework, this trailer was itself made of glass fibre plastics and could be used for the carriage of goods.

DEPTH INDICATOR

An echo-sounding equipment for inshore work was displayed by the British Ferrograph Recorder Company, Limited, 131 Sloane-street, London, S.W.1, which has a range of 100 ft. or, in metric

The pleasures of boating and caravanning are combined in the Amphibian Otter, a caravan which, launched from its trailer, becomes a houseboat.



A Thornycroft launch typifies many of the craft on display at the National Boat Show.

Among the novelties was the Amphibian Otter, a 16 ft. 6in. caravan which can be towed behind an 8 h.p. car, and on arrival at a river bank can be slid off its wheel chassis to form a house boat with sleeping berths for four. In this form it is propelled by an outboard motor which, when not in use, can be stored in one of the lockers at the stern; a 1½ h.p. engine will give the house boat the speed of approximately 4 m.p.h. Fitments include a folding kitchen and toilet accommodation. Being only 6 ft. 8 in. wide it can be used on canals with 7 ft. locks and the draft is only 12 in. An interesting feature of the chassis is that rubber suspension has been used for the wheels so that the framework does not rise when the "caravan" is removed, and so makes its replacement comparatively simple.

Safety was well represented by exhibits of life rafts and floats of sizes varying from a large raft carrying several people to a single float for a small infant. Much interest was caused by a working demonstration with a helicopter, of air/sea rescue. Safety was also exemplified by the biggest life-boat, the "Richard Vernon and Mary Garforth of Leeds," which is 46 ft. 9 in. long. There was, too, a 14 ft. 6 in. ship's life-boat, made entirely from Jabloc expanded plastics, which is claimed to be completely unsinkable for the very good reason that the density of the material used is less than that of water; should therefore the boat be taken down to the bottom, it will immediately rise to the surface under its own buoyancy. The built-in buoyancy tanks do not rely on air which can escape by damage, but are filled with expanded plastics blocks of very low density.

Although it has been said that yachting is a rich man's pastime, it would appear that the "do it yourself" spirit has made great progress

units, 30 m. It is designed to operate at approximately 150 kcs. and takes soundings at the rate of 24 per second. Power can be obtained from either 12 or 24 volt batteries, the consumption being about 30 watts. A motor unit with contacts on the shaft triggers the transmitter, which is connected to an under-water transducer fitted very simply to the hull of the craft. Two models of the transducer are made for fitting to hulls of different angles. The resulting sound-wave passes to the bottom of the water, and is reflected back, collected by the same transducer and the electrical impulse so generated is amplified. The depth is indicated by a flashing lamp which is rotating behind a scale in the indicator unit. The lamp flashes as it passes the zero reading, which corresponds to the moment of transmission, and again at the reception of the echo. Because of the high rate of sounding, the flashes appear on the dial as a steady arrow of light, sufficiently bright to be seen clearly when the ambient illumination incident upon the face of the scale is as high as 125 ft. candles. In bright sunlight a visor is necessary. Only two controls are required to operate the sounder and both are fitted to the indicator unit. They are the on/off switch and the gain control. The complete equipment thus consists of three items, the indicator unit, calibrated in feet or metres as required, the transmitter/receiver unit which is in a water-tight box and can be mounted in any convenient position, and the transducer unit, mounted outside of the hull. All wearing parts can be replaced, and the motor is driven from a constant-frequency vibrator which maintains the speed of rotation within very narrow limits. The error quoted by the manufacturers is plus or minus 4 per cent. of the depth worked, or 6 in., whichever is the greater. The minimum depth from the transducer face which can be satisfactorily indicated is 2 ft. An interesting alternative application is for measuring the depth of water in large tanks. In this case the transducer is mouned on the bottom and the echo is reflected from the surface.

Among other equipment, but this time for use on larger vessels, was the Minihaler Inter-com system, made by Lee and Son Development Company, 1a Waldram-place, London, S.E.23. As many as six receiving/transmitting units can be driven from the single mains pack which is supplied by either a 12 or 24 volt battery. Speech at one unit is relayed to all the others simultaneously. The system does not involve the use of electronic valves.

For many auxiliary purposes, hydraulic power is very convenient. Examples of windlasses, winches, capstans and steering gear were exhibited by A. W. Smallwood, Pwllheli, North Wales. The Junior Hydro-hauler capstan was demonstrated in operation, completely submerged in water, to the action of which it is entirely resistant. As with the other winches and capstans, the speed can be varied by controlling the pump, and a creep can be obtained by fitting a control valve across the two hydraulic pipes. The maximum hauling effort can be limited to suit the breaking strain of the gear by mounting a variable screwdown safety control on top of the pump unit. The Junior has a power rating of 600 lb.-in., with a waisted drum of 8¼ in. base diameter. Hauling speeds in excess of 100 ft. per minute are obtainable. Other models are available either in the form of winches or capstans with powers up to 9,000 lb.-in. The pumps can be directly driven by belt from the main engines and are fitted with clutches to control the operation.

The steering gear consists of two rams operated by a normal steering wheel and geared so that they move in opposite directions. They are connected by copper pipe to two other rams which act directly on the tiller bar giving a torque of about 10,000 lb.-in. on the rudder post. The equipment is extremely simple to install on any boat and sizes are available for craft 25 ft. in length and above. Use of plastics materials for many parts has enabled the production costs to be kept low.

A portable capstan for beach use was the Fifer made by James M. Miller and Company, Limited, St. Monance, Fife. The capstan is driven by a 3 h.p. air-cooled engine, and the two units are mounted on a two-wheel trailer. Sprags on the trailer dig into the beach to counteract the haul of the rope, and electric flood lighting is mounted above the trailer so that it can be used during darkness. It was originally designed for seine netting and is fitted with two warping drums, a large and a small. It can also be used for hauling cobbles up the beach.

ATOMIC REVIEW

A Flux for Fusion

No fusion data without fission work—Crying need for an advanced accelerator—Fusion catalysed by mesons at low temperatures—British and American firms receive contracts for fusion research—Fusion by shock waves—Direct conversion of fusion energy into electricity—Thermonuclear reactions might require vast tank—Fusion to release geothermal energy—Fusion fundamentals—Courses and articles on fusion—Proton properties—British research centre with multi-million volt accelerator under discussion—Wild men of Windscale.

FUSION NEWS

The recent discovery of a fresh approach to the hydrogen fusion reaction, and the news that contracts to carry out fusion studies have been awarded to several British companies and universities has aroused renewed interest in this process as a potential source of power. It is thus opportune, particularly since a start has now been made on the fission reactor programme, to survey such fusion developments as have been made public in recent months. In the absence of full knowledge concerning the progress of research on controlled fusion, there is necessarily some concern as to when resources should be diverted from fission to fusion studies, and it is significant that access to fusion data in the United States is to be granted only to those companies which can show a considerable expenditure on fission reactor projects. It is also noteworthy that one of the British guests at the recent American Nuclear Society conference on fusion topics was Mr. J. C. C. Stewart, director of technical policy for the U.K.A.E.A. Industrial Group. Another point that arises is the immense practical importance of particle accelerators; it is apparent from an American discovery discussed below that without an accelerator combining high energy and high beam intensity, Britain cannot keep abreast of new power ideas. It should be emphasised, however, that the discovery, which was made on a laboratory scale, is a very long way yet from practical application. In this section we report news on fusion that has been published since our last note on the subject. Previous references have appeared in ENGINEERING on October 10 (page 443); August 10 (page 187) and July 27 (page 124) and also in vol. 181 (pages 318, 322, 355 and 409) and vol. 180 (page 235).

Cold Fusion

Until now the fusion reaction between atomic nuclei has been associated exclusively with high temperatures. Nuclei carry positive charges and consequently repel each other with considerable force; thus, if two nuclei are to approach each other sufficiently closely for a reaction to occur, means must be found of overcoming this repulsion. So far attention has been mainly devoted to battering ram methods, in which nuclei of hydrogen (each comprising one proton and carrying one positive charge) or deuterium (one proton, one neutron, and one positive charge) are accelerated to high velocities so that their inertia is sufficient to penetrate the repulsion barrier. In terms of kinetic theory these high velocities are effectively high temperatures, so that to initiate a reaction considerable heat energy must be supplied. It is clear that the smaller the positive charge on the nucleus, the more likely it is that a reaction will take place; thus an isotope of hydrogen—and preferably a heavy isotope with its increased inertia—offers the best chance of achieving nuclear fusion. (Fission of heavy elements is simpler to achieve since it can be effected by the impact of neutrons, which being uncharged are not repelled by the atomic nucleus.) Some possible fusion reactions are given later in this article.

On the surface is appears that the production of temperatures exceeding 10 million deg. C. are the only feasible approach to the problem of fusion; indeed the word "thermonuclear" has become associated with it. Elements are defined by the number of positive charges on their nucleus, so that the formation of heavier elements from light elements necessarily involves the union of positively charged particles or protons. For this reason there would seem to be no alternative to the battering ram technique, and investigators have therefore concentrated on the generation of high velocities (or high temperatures) by the direct application of heat, as in the thermonuclear bomb, or by means of accelerators, magnetic fields, electric currents or possibly chemical explosives. At California University, however, a method of circumventing this difficulty has been devised, whereby the structure of the atom itself is modified. Reference has been made to it in a paper presented before the American Physical Society by Dr. L. W. Alvarez, the leader of the team responsible for the discovery.

The size of a hydrogen (or deuterium) atom is determined by the path of its single orbital electron, as illustrated in Fig. 1 (*a*). The electron is negatively charged so that effectively the whole atom is electrically neutral. Not until the bombarding proton or deuteron (nucleus of deuterium

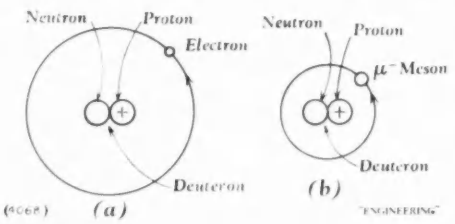


Fig. 1 Hitherto, the hydrogen fusion reaction has been associated exclusively with high temperatures. Recently it has been shown that fusion can be accomplished at sub-zero temperatures by modifying the structure of the hydrogen or deuterium atom as shown schematically.

atom comprising one proton and one neutron) has passed within the orbit does the repelling force come into play. Thus if the size of the orbit could be reduced in some way, the time in which the repelling force acted would be correspondingly diminished. In terms of mechanics this would seem possible only if the electron were replaced by some heavier particle, also, of course, carrying a single negative charge. This can be seen from elementary mechanics equations, which, however, only roughly apply. The force necessary to confine a body to motion in a circle is $\frac{m v^2}{r}$, where m is its mass, v its tangential velocity and r the radius of the arc in which it moves. This must be equal in the case of the atom to the force of electrical attraction, which varies inversely as the square of the distance between the charged particles. Thus:

$$\frac{m v^2}{r} = \frac{k}{r^2}$$

or if we assume (with some temerity) a constant velocity, m varies as the reciprocal of the radius. Most of these assumptions, for example that an electron travels in a circle, are not strictly valid but it is nevertheless apparent that a particle of larger mass will probably tend to move in a smaller orbit, as shown in Fig. 1 (*b*).

Now there are quite a number of known particles to choose from (over 20), and one at least fits the conditions. It is the negative μ meson, which as its name implies is intermediate in mass between the electron and the proton and is in fact about 207 times as massive as the electron. Mesons are found in cosmic radiation and have also been produced in high powered accelerators such as the University of California's 6 GeV Bevatron (6 GeV = 6×10^9 eV). (Accelerators are not the only artificial source of fast moving particles; nuclear reactors have been used to provide both neutrons and neutrinos, and have the advantage that particles are produced in great abundance—see ENGINEERING, July 27, 1956, page 124.) The manner in which a μ meson is produced from a proton may be gathered from Fig. 2, which is a reproduction of a bubble chamber photograph, and its associated key. It is noteworthy that the photograph was taken at the University of California and that Dr. Alvarez was responsible for developing the bubble chamber in its present form, in which particle tracks are produced in superheated liquid hydrogen. Generally, a μ meson may be obtained by accelerating a proton or hydrogen nucleus to a high energy; subsequent collision between the proton and some other nucleus eventually (after certain other changes as indicated in the key to Fig. 2) gives rise to the short lived π meson which promptly decays into a μ meson.

Liquid hydrogen, which boils at about 23 deg. K. (− 250 deg. C.), was used as the basic material of the experiment, since in this way a high concentration of hydrogen nuclei could be obtained. Negative μ mesons formed in an accelerator were injected into the liquid, whereupon they became associated with hydrogen nuclei, taking up orbits and replacing the electrons. Since the mass of a μ meson is more than 200 times that of an electron, the size of an atom so formed (defined by the meson orbit) is roughly 200 times as small as that of a normal hydrogen atom. The new atoms have been variously called "mesic" and "mesonic" atoms. Being so small, the mesonic atoms can approach each other so that the nuclei are separated by only a small distance when repulsion due to the positive charges takes effect. The inertia of the comparatively slowly moving atoms in the liquid hydrogen is thus sufficient to overcome the repulsion barrier, and there is a considerable probability that union will occur. Once fusion has taken place the meson is theoretically free to replace the electron of another atom, so that the reaction would then be continuous. Thus the meson is in effect a catalyst, and serves broadly as a flux for fusion.

Unfortunately, like its predecessor the π meson, the μ meson is short-lived, with a mean life of about 2×10^{-6} seconds, decaying into an electron and two neutrinos. It is thus unlikely that one fusion occurs per meson present; in fact the proportion is probably very much lower. The meson therefore offers little hope of sustaining a continuous fusion reaction. It follows that the energy balance is poor, since the energy expended in producing one meson is necessarily much greater than that evolved in one fusion. The energy of the π meson, which precedes the μ meson, is said to be about 140 MeV, which owing to losses, wasted particles and other causes is bound to be much less than the energy absorbed by the accelerator per useful meson produced. On the other hand, the energy released in the formation of one helium nucleus from two deuterons, which as indicated below is the most favourable hydrogen fusion reaction, is only 24 MeV. Thus each meson would have to take part in many successive fusion reactions before a satisfactory energy balance could be obtained. In any case the capital cost of an accelerator is immense.

What is important is that the Californian team have detected some examples of fusion in the circumstances described, and that these circumstances do not involve the use of high temperatures. Hitherto, the immense temperatures thought to be necessary have represented the main stumbling block, as will be seen from some of the following notes. The next problem is to discover a long-lived intermediate particle carrying a negative charge. This would seem a very unlikely prospect. But even Rutherford is understood to have said that the chance of obtaining useful power from nuclear reactions (including fission) corresponded to the chance of scoring a hit with a peashooter on a fly loose in the Albert Hall. In fact, Dr. Alvarez says the Soviet physicist Alikhanian has published evidence of a

very long-lived particle. One report suggests that its mean life might be of the order of 20 minutes, which would be sufficient to give some 10^9 fusions per meson. If the existence of this particle is confirmed, the problem of controlling the fusion reaction to produce commercial power is a little nearer to solution.

Firms Study Fusion

One British firm known to have been working in this field for some time is Associated Electrical Industries, who have recently been seeking additional staff to cope with their U.K.A.E.A. contract. Dr. T. E. Allibone, director of the A.E.I. research laboratories, Aldermaston, where this work is carried out, is recently reported to have said that in 10 years we should understand how to control the hydrogen-fusion process and in another 10 years it would be sound engineering practice. Academician I. V. Kurchatov (U.S.S.R.) is understood to have referred to A.E.I. work in his lecture at Harwell (see ENGINEERING, May 11, page 323). American industry is also undertaking research of this kind and some 100 companies have applied for permits. It has been suggested that the recent tripartite agreement between Britain and the United States may have been prompted by successful British studies on thermonuclear reactions.

Shock Waves and Whirlpools

Last month, Dr. Allan C. Kolb, of the U.S. Naval Research Laboratory's Radiation Division, speaking at the meeting of the American Nuclear Society referred to in the paragraphs on cold fusion, described the use of shock waves to produce the high temperatures necessary to initiate the fusion reaction. Preliminary experiments indicate that it is possible to stop high-velocity shock waves by a magnetic field, thereby converting the energy in the ordered motion into thermal energy. In his experiments using magnetic fields Dr. Kolb achieved, in a minute drop of heavy water, particle velocities approaching 500,000 ft. per sec. These velocities were sustained for less than 10^{-6} sec. Similar velocities have been obtained by Dr. W. H. Bostick in a whirling plasma confined by electromagnetic forces.

Direct Conversion

Progress on the United States Project Sherwood, which is concerned with fusion studies, has been reported by Mr. E. Teller speaking at an earlier meeting of the American Nuclear Society. It would solve the fuel problem for ever, required no fuel processing, was safer because there was no tendency to run away, and there were far fewer radioactive poisons. He considered that thermonuclear fusion would pave the way to direct conversion of nuclear into electrical energy, without a thermal cycle, since there was a direct link between the magnetic lines of force and the plasma (see Kurchatov article). Just as the directed motion of currents could be used to create magnetic fields to contain the plasma, so the motions of the plasma—after the energy producing fusions have taken place—could be used to produce directed electric currents. The main difficulty was to confine the plasma and keep it at extremely high temperatures within a wall that would not absorb heat. One way was to contain it in a " magnetic bottle," i.e. within lines of force, but the bottle was not easily made leakproof; the lines of force behaved like rubber bands, tending to snap, so releasing the plasma. Project Sherwood was tackling this problem. This ideal of direct conversion has been extended by Dr. A. Bishop, of the United States A.E.C. Research Division, who said recently that in a deuteron-deuteron reaction more than two-thirds of the energy released appeared as charged particles. These would not be able to escape from the electromagnetic field confining them and the resulting interaction might generate electric power directly. Only a minute amount of fuel would be in the reactor chamber at one time.

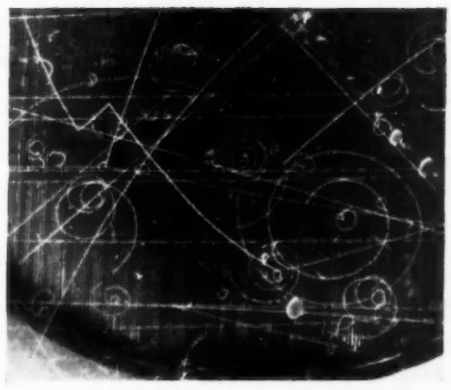
Containing Tank

An analysis of the possibilities of thermonuclear power plants, which was published in a recent issue of *Jet Propulsion*, the journal of the American Rocket Society, indicates that the smallest thermonuclear reactor that could be built by known techniques would produce heat to generate five times as much electricity in a year as was produced throughout the United States in 1954. Such a " minimum " thermonuclear reactor would, however, require the construction of a tank 330 ft. in diameter and 3,300 ft. long. It would have to be strong enough to withstand pressures of about 1,500 lb. per sq. in. Hot gases might be led off and fed at much reduced temperatures into a conventional gas turbine. The analysis was prepared by Dr. Hsue-Shen Tsien. Dr. Tsien estimates that a temperature of 10 million deg. C. is the minimum at which the heavy hydrogen atomic nuclei can be " burned " in a reactor to produce helium and release energy. Temperatures of this kind could be achieved only in the centre of a " flame " of heavy hydrogen (deuterium) particles the size of a 200 ft. by 400 ft. cylinder. Radioactivity from the thermonuclear reaction would be little problem. Gaseous deuterium could be introduced into the reaction chamber through the walls, thus serving to cool them and protect them from evaporating.

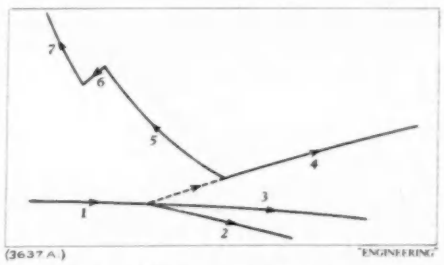
Reservoirs and Geothermal Energy

Two interesting but rather alarming methods of applying thermonuclear fusion are suggested in a book entitled *Les Applications de l'Explosion Thermonucléaire*, by M. Camille Rougeron. Firstly, the author considers that hydrogen bomb explosions might be used to create vast artificial reservoirs wherever they are called for by technical and economic considerations. Nature, he says, is not generous in this respect. Secondly, he believes that the vast energy of geothermal sources might be released by suitably controlled thermonuclear explosions. He envisages a series of chambers at increasing depths, blasted successively by first conventional explosives, second a fission bomb and finally by a fission initiated fusion bomb to give access to great depths. Underground boilers would then be installed to make use of the earth's subterranean heat.

Initially the heat might be employed to distil sea water for irrigation purposes. This is a proposal in the grand manner, and though it is possible that the Sahara might be developed by energy obtained in this way, it is unlikely that within the limited confines of the United Kingdom it would find much application, especially when we learn of the opposition to modest atomic power stations.



University of California photograph



(3637A) "ENGINEERING"

Key to the most striking sequence of tracks in the accompanying illustration. There appear to be four successive events which may possibly be described as follows: a π^- meson (1), of 273 electron masses, strikes a proton, scatters it (2), and produces a K^- meson (3), of 966 electron masses, and a neutral 0^0 meson also of 966 electron masses. The neutral meson leaves no track and is shown dotted. It decays into a π^- meson (4) and a π^+ meson (5). The π^+ meson stops in the hydrogen and decays into a μ^+ meson (6), of 207 electron masses, which remains in the hydrogen and decays into a positive electron (7), which passes through the top glass of the chamber.

Fig. 2 To achieve the fusion of hydrogen nuclei at low temperatures the so-called negative μ meson is used as catalyst. Mesons can be produced artificially by a mechanism similar to that shown in this bubble chamber photograph and key.

Fundamentals of fusion

Some conceivable fusion reactions are as follows:

hydrogen + deuterium → helium 3 + 5·4MeV
deuterium + deuterium → tritium + proton + 4MeV
deuterium + deuterium → helium 3 + neutron + 4MeV
deuterium + deuterium → helium 4 + 24MeV
deuterium + tritium → helium 4 + neutron + 17MeV
hydrogen + lithium 7 → 2 helium 4 + 17MeV
deuterium + lithium 6 → 2 helium 4 + 17MeV

The released energy comes from slight losses of mass in accordance with Einstein's formula

$$e = mc^2,$$

where e is the energy evolved, m the mass lost and c the velocity of light.

The residue of all these reactions is a gas which can safely be released. It should be noted that in practice a cyclic reaction would probably be used such as those discussed in our issue of July 27, page 124. For reactions to occur, temperatures as high as 100 million deg. C. have been suggested, though a figure as low as 14 million deg. C. has also been given. Academician Kurchatov stated taat a temperature of 200,000 deg. C. would be necessary to obtain one free neutron per second per gram of heavy water, and for a measurable result 500,000 deg. C. would be required. At this temperature a gram of water would occupy a cube of 100 ft. edge. The dimensions of the tank referred to above are thus explained.

Generally, as stated by Dr. P. C. Thonemann in an article in *Nuclear Power*, an apparatus for achieving controlled thermonuclear reactions must be such that the gas is prevented from dispersing and, in addition, because of the immense gas pressures involved, the particle density must be maintained at a level so low that the mean free path for radiation absorption is much greater than the dimensions of the gas. (The particle density in the experiments described by Academician Kurchatov is thought to have been about 10^{18} per cub. cm.) Under these conditions the reaction need not be too explosive, even if the reaction products are trapped and made to heat the gas. It can be calculated that for the energy generated just to exceed the energy radiated, the temperature must be about 10^8 deg. K. for the deuterium-deuterium (D-D) reaction, and 3×10^8 deg. K. for the tritium-deuterium (T-D) reaction. If a reasonable heat recovery in terms of the energy supplied is to be obtained, some 10 per cent. of the fuel initially present must be burnt; to achieve this, it has been estimated the temperatures would have to be maintained for between 10^{-3} and 10^{-2} second, though means may be discovered of shortening this.

The deuterium-deuterium temperature is based on the assumption that tritium, which is a by-product of the reaction, can be burnt and contributes to the energy yield, giving 25 MeV per D-D neutron. Since tritium is not a naturally occurring isotope of hydrogen it must be bred by utilising neutrons from the T-D reaction. This can be effected by capturing them in naturally occurring lithium 6, which then breaks up

yielding helium and the required tritium. The resulting energy yield is 22 MeV per T-D neutron.

Finding Out About Fusion

In December the American Nuclear Society held a conference in Washington which included a panel on controlled fusion power, with five speakers who have been active in Project Sherwood. Professor Richard F. Post of Livermore covered general physical principles and measurement problems; Professor Winston H. Bostick, of the Stevens Institute of Technology, discussed the behaviour of plasmoids; Mr. James L. Tuck, of Los Alamos, considered pinch-effect and its instabilities; Dr. Alan C. Kolb, of the U.S. Naval Research Laboratory, spoke on the production of high temperatures by shock waves; and Mr. Edward Frieman, of Princeton, outlined an energy principle for hydromagnetic stability problems. Reference to some of these contributions has been made in preceding paragraphs. British representatives present were Mr. J. C. C. Stewart, director of technical policy for the U.K.A.E.A. Industrial Group; Mr. E. Long, of the Industrial Group, who spoke on Calder Hall, and Mr. G. H. Kinchin of A.E.R.E., Harwell, who gave a paper on fast reactor stability.

The Stevens Institute of Technology, Hoboken, N.J., is offering a course on controlled thermonuclear fusion under Professor W. H. Bostick, who had previously been engaged on the thermonuclear research project at the University of California. The course will cover theory, proposed processes, techniques and problems of application. A 24 page article on thermonuclear principles by Professor Post appeared in the July, 1956, issue of *Reviews of Modern Physics*, and further details of the Kurchatov experiments in the third issue of the Soviet journal *Atomnaya Energiya*.

Picture of the Proton

A description of the proton has been published by Dr. Robert F. Hofstadter, of Stanford University, U.S.A. It is, he says, 3×10^{-13} in. across and is something like a peach, soft on the outside with a hard core.

Physics Centre with Accelerator

The latest discovery in the field of nuclear fusion underlines the importance of particle accelerators, and it is encouraging to learn that a multi-million volt machine may form part of a national centre for nuclear physics at present under discussion. Discussing this in a lecture to the Science Masters' Association, Professor N. F. Mott, of the Cavendish Laboratory, Cambridge, said that the establishment would house the largest equipment Britain could build and might be sited near the Atomic Energy Research Establishment at Harwell. It has been suggested that the centre would correspond to the Brookhaven Laboratory in New York. As an indication of the expenditure required for a centre of this kind, the cost of the 25 GeV proton-synchroton under construction at the CERN establishment in Switzerland will be about £7 million. As stated previously in ENGINEERING, an accelerator of between 6 and 7 GeV is planned for Harwell; it is to have a very high beam intensity. The probability of obtaining a required particle is a function of beam intensity rather than power; indeed mesons can be obtained at energies as low as 300 MeV. Britain's highest rated accelerator, that at Birmingham, gives energies of 1,000 MeV.

Postscript

Reports that under radiation, tulips have reverted to their condition of a 1,000 years ago conjure up some alarming thoughts. This discovery was made at the U.K.A.E.A. Technological Irradiation Group establishment at Wantage, where such problems as irradiation sterilisation of vaccines and foods are also investigated. No doubt, members of atomic energy establishments will now be on the lookout for signs of savagery in their fellows, and already, we understand, some wild men of Windscale have flung away the flimsy trappings of civilisation and taken to the hills.

NOTICES OF MEETINGS

British Institution of Radio Engineers

GLASGOW
"Industrial Applications of High-Speed Pen Recorders," by B. Kasler. Scottish Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Thurs., Jan. 17, 7 p.m.
TREFOREST
"Radio Techniques in Post Office Engineering," by C. T. Lamping. South Wales Section. Glamorgan Technical College, Treforest. Wed., Jan. 16, 6.30 p.m.

Building Centre

LONDON
Film on "Colt Canadian Cedarwood Shingles," exhibited by W. H. Colt (London), Ltd. Wed., Jan. 16, 12.45 p.m.

Chemical Engineering Group

LONDON
"Use of Multi-Wall Paper Bags in the Chemical Industry," by A. R. Hutchinson. Society of Chemical Industry, 14 Belgrave-square, S.W.1. Tues., Jan. 15, 5.30 p.m.

Chemical Society

ABERDEEN
"Character of Paint: Newer Developments," by A. T. Rudram. Aberdeen Branch. Marischal College, Aberdeen. Fri., Jan. 18, 7.30 p.m.
BRISTOL
"Some Aspects of Radiation Chemistry," by Professor F. S. Dainton. Bristol Branch. Chemistry Department, The University, Bristol. Thurs., Jan. 17, 7 p.m.
LEEDS
"Problems of Air Pollution," by G. Nonhebel. Leeds Branch. Chemistry Lecture Theatre, The University, Leeds. Mon., Jan. 14, 6.30 p.m.
MANCHESTER
"Studies of Knock and Anti-Knock by Kinetic Spectroscopy," by Professor R. G. W. Norrish. Manchester Branch. Chemistry Lecture Theatre, The University, Manchester. Wed., Jan. 16, 6.30 p.m.

Combustion Engineering Association

MANCHESTER
"Application of Back Pressure and Passout Generation," by J. R. Wilkins. North Western Section. Engineers' Club, Albert-square, Manchester. Wed., Jan. 16, 10.30 a.m.

Diesel Engineers and Users Association

LONDON
"World Supplies of Oil," by M. E. Hubbard. Caxton Hall, off Victoria-street, S.W.1. Thurs., Jan. 17, 2.30 p.m.

Illuminating Engineering Society

GLOUCESTER
"X-Rays in Industry," by K. P. Alsop. Gloucester and Cheltenham Centre. Fleece Hotel, Westgate-street, Gloucester. Tues., Jan. 15, 6.30 p.m.
LIVERPOOL
"A Review of Street Lighting in Great Britain," by C. C. Smith. Liverpool Centre. Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool. Tues., Jan. 15, 6 p.m.
MANCHESTER
"The Evolution of the Institution's Code," by H. C. Weston. Manchester Centre. Offices of the North Western Electricity Board, Town Hall, Manchester. Thurs., Jan. 17, 7 p.m.

Incorporated Plant Engineers

BIRMINGHAM
"Arc Welding," with film, by F. A. Thomas. Birmingham Branch. Imperial Hotel, Temple-street, Birmingham. Fri., Jan. 18, 7.30 p.m.
BLACKBURN
"Modern Chain-Making Techniques," by W. Gibson Biggart. Blackburn Branch. Golden Lion Hotel, Blackburn. Thurs., Jan. 17, 7.30 p.m.
CHESTER
"Instrumentation and Automation," by R. J. F. Howard. Merseyside and North Wales Branch. Stafford Hotel, City-road, Chester. Thurs., Jan. 17, 7.15 p.m.
DUNDEE
"The Manufacture of Components," by J. Lomax. Dundee Branch. Mathers Hotel, Dundee. Mon., Jan. 14, 7.30 p.m.
ROCHESTER
"Steam Raising by Oil Fuel," by H. W. Hastings. Kent Branch. King's Head Hotel, High-street, Rochester. Wed., Jan. 16, 7 p.m.

Institute of British Foundrymen

IPSWICH
"Foundry Developments," by D. Killingworth. East Anglian Section. Public Library, Ipswich. Tues., Jan. 15, 7.30 p.m.
NORTHAMPTON
"Foundry Brains Trust." Northampton Section. Plough Hotel, Northampton. Sat., Jan. 19, 6 p.m.
SLOUGH
"Coreblowing," by G. W. Fearfield. Slough Section. Offices of High Duty Alloys Ltd., Slough. Tues., Jan. 15, 7.30 p.m.
SOUTHAMPTON
Film Evening. Southampton Section. Technical College, St. Mary's-street, Southampton. Wed., Jan. 16, 7.30 p.m.

Institute of Marine Engineers

LONDON
"Radio Aids to Marine Navigation," by Captain R. G. Swallow, R.N. (Retd.). Student Lecture. Mon., Jan. 14, 6.30 p.m.*
KINGSTON-UPON-HULL
Film "Ocean Highways," introduced by A. R. Kenworthy. Kingston-upon-Hull and East Midlands Section. Royal Station Hotel, Kingston-upon-Hull. Thurs., Jan. 17, 7.30 p.m.
MIDDLESBROUGH
"Safety at Sea," by Stewart Hogg. North East Coast Section. Cleveland Scientific and Technical Institute, Middlesbrough. Thurs., Jan. 17, 6.15 p.m.

Institute of Metals

BIRMINGHAM
"Some Metallurgical Aspects of a Gas Turbine Engine," by S. Heslop. Birmingham Local Section. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham. Thurs., Jan. 17, 6.30 p.m.
SWANSEA
"Fatigue," by Major P. Litherland Teed. South Wales Local Section. Department of Metallurgy, University College, Singleton Park, Swansea. Tues., Jan. 15, 6.45 p.m.*

Institute of Road Transport Engineers

LONDON
"Selection and Use of Petroleum Products for Road Transport," by C. G. Tresidder. Royal Society of Arts, John Adam-Street, Adelphi, W.C.2. Thurs., Jan. 17, 6.30 p.m.
BRISTOL
"Exhaust Brake Design and Operation," by A. G. Slee and W. K. Cox. Western Centre. Royal Hotel, Bristol. Tues., Jan. 15, 6.30 p.m.
LEEDS
"Wear and Tear," by J. Johnson. Yorkshire Centre. Great Northern Hotel, Wellington-street, Leeds, 1. Thurs., Jan. 17, 7.30 p.m.

Institution of British Agricultural Engineers

NEWCASTLE-UPON-TYNE
"Modern Crop-Spraying Technique," by F. W. Morris. Northern Centre. Offices of the North Eastern Electricity Board, Carliol House, Newcastle-upon-Tyne. Mon., Jan. 14, 6.45 p.m.
PERTH
Discussion on "Agricultural Machinery." Scottish Centre. Station Hotel, Perth. Tues., Jan. 15, 7.30 p.m.

Institution of Chemical Engineers

CHESTER
"Vocation Training for Chemical Engineers," by A. J. Carter. North Western Branch. Grosvenor Hotel, Chester. Tues., Jan. 15, 7 p.m.
LEEDS
"Equilibrium Flash Vaporisation of Coal Tar and Coal-Tar Fractions," by D. K. H. Briggs and F. Popper. North Western Branch, The University, Leeds. Wed., Jan. 16, 7 p.m.

Institution of Civil Engineers

LONDON
"Daer Water Supply Scheme," by Harold Kerr and E. B. Lockett. Tues., Jan. 15, 5.30 p.m.*

Institution of Electrical Engineers

LONDON
Discussion on "The Influence of Maintenance Requirements on the Design of Industrial Electrical Equipment," opened by H. C. Fox and J. H. Harris. Mon., Jan. 14, 5.30 p.m.*
Discussion on "Distribution of Power Supplies in Electrical Laboratories," opened by H. E. Dance and Dr. P. E. Soper. Education Discussion Circle. Tues., Jan. 15, 6 p.m.*
"Electricity in Modern Commercial Horticulture," by C. A. Cameron Brown and A. W. Gray. Utilization Section. Thurs., Jan. 17, 5.30 p.m.*
CARDIFF
"Flat Pressure Cable," by J. S. Mollerhoj, A. M. Morgan and C. T. W. Sutton. Western Centre. South Wales Institute of Engineers, Park-place, Cardiff. Mon., Jan. 14, 6 p.m.
CHELMSFORD
"Auto-Following Radar Systems," by J. A. Barber. London

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Chemical Engineering Group, 16 Belgrave-square, London, S.W.1. (BELgravia 3647.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Combustion Engineering Association, 6 Duke-street, St. James's, London, S.W.1. (WHItehall 5536.)
Diesel Engineers and Users Association, 19 Old Queen-street, London, S.W.1. (TRAfalgar 5597.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester 3. (Blackfriars 6178.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Metals, 17 Belgrave-square, London, S.W.1. (BELgravia 3291.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of British Agricultural Engineers, 6 Buckingham-gate, London, S.W.1. (TATe Gallery 8589.)
Institution of Chemical Engineers, 16 Belgrave-square, London, S.W.1. (BELgravia 3647.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineering Designers, 38 Portland-place, London, W.1. (LANgham 8847.)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Mining and Metallurgy, 44 Portland-place, London, W.1. (LANgham 3802.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of Public Health Engineers, 118 Victoria-street, London, S.W.1. (VICtoria 3017.)
Institution of the Rubber Industry, 4 Kensington Palace-gardens, London, W.8. (BAYswater 9101.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Reinforced Concrete Association, 94-98 Petty France, London, S.W.1. (ABBey 4504.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Microscopical Society, Tavistock House South, Tavistock-square, London, W.C.1. (EUSton 2048.)
Royal Statistical Society, 21 Bentinck-street, London, W.1. (WELbeck 7638.)
Sheffield Metallurgical Association, 66 Ringstead-crescent, Sheffield 10. (Sheffield 62144.)

Graduate and Student Section. Public Library, Chelmsford. Tues., Jan. 15, 7 p.m.
FARNBOROUGH
"Time Sharing as a Basis for Electronic Telephone Switching: A Switched Highways System," by F. C. Nelson. Southern Centre. R.A.E. Technical College, Farnborough. Wed., Jan. 16, 7.30 p.m.
NEWCASTLE-UPON-TYNE
"Choice of Insulation and Surge Protection of Overhead Transmission Lines of 33 kV and Above," by A. Morris Thomas and D. F. Oakeshott. North Eastern Centre. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Mon., Jan. 14, 6.15 p.m.
WORKINGTON
"Underground Lighting in Coal Mines," by Dr. C. D. J. Statham. North Eastern Centre. College of Further Education, Workington. Tues., Jan. 15, 7 p.m.

Institution of Engineering Designers

LONDON
"Demands of Inspection on Engineering Design," by E. W. Greensmith. Tues., Jan. 15, 6.45 p.m.

Institution of Engineers and Shipbuilders in Scotland

GLASGOW
"Experimental Techniques for Hydraulic Machinery Research," by Dr. S. P. Hutton. Tues., Jan. 15, 6.30 p.m.

Institution of Mechanical Engineers

LONDON
Discussion on "Is There a Future for the Diesel Engine in Combination with the Gas Turbine?" Internal Combustion Engine Group. Tues., Jan. 15, 6.45 p.m.*
"Industrial Cooling-Water Equipment," by B. Colledge. London Graduates' Section. Wed., Jan. 16, 6.30 p.m.*
Thomas Lowe Gray Lecture: "The Salvaging of Ships with Particular Reference to the Empress of Canada," by Captain W. R. Colbeck. Fri., Jan. 18, 6 p.m.
MANCHESTER
Annual General Meeting. "Power Station Auxiliary Plant," by G. F. Kennedy and F. J. Hutchinson. North Western Branch. Engineers' Club, Albert-square, Manchester. Thurs., Jan. 17, 6.45 p.m.

Institution of Mining and Metallurgy

LONDON
"Operations at the Ethel Asbestos Mine, Southern Rhodesia," by N. M. Airey; "The Kliphuis Crocidolite Deposits," by W. E. Sinclair; and "Prospect Sampling by Air-Flush Drill," by B. W. H. Harding. Geological Society, Burlington House, Piccadilly, W.1. Thurs., Jan. 17, 5 p.m.*

Institution of Production Engineers

LONDON
"A Modern Inspection and Standards Room Practice," by G. S. Sharp. London Section. Royal Empire Society, Craven-street, W.C.2. Thurs., Jan. 17, 7 p.m.
DONCASTER
"Materials Handling: A Challenge to British Industry," by A. G. Hayek. Doncaster Section. Danum Hotel, Doncaster. Tues., Jan. 15, 7 p.m.
EDINBURGH
"Computer-Controlled Machine Tools," by G. S. Kermack. Edinburgh Section. North British Hotel, Princes-street, Edinburgh. Wed., Jan. 16, 7.30 p.m.
GLASGOW
"Profiling: Production Methods on Lathes," by J. T. Lang. Glasgow Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Thurs., Jan. 17, 7.30 p.m.
PETERBOROUGH
"High Cost of Low Overheads," by C. H. Starr. Peterborough Section. White Lion Hotel, Church-street, Peterborough. Tues., Jan. 15, 7.30 p.m.

Institution of Public Health Engineers

LONDON
"Problems of Pumping Liquids," by A. J. Clements. Caxton Hall, off Victoria-street, S.W.1. Tues., Jan. 15, 6 p.m.

Institution of the Rubber Industry

CARDIFF
"Production and Work Study," by J. B. Kitchen. South Wales and Monmouthshire Section. Angel Hotel, Cardiff. Mon., Jan. 14, 7.30 p.m.
LEICESTER
"Modern Developments in the Use of Nylon in the Rubber Industry," by J. M. Page. Leicester Section. Bell Hotel, Leciester. Fri., Jan. 18, 7.30 p.m.

Institution of Structural Engineers

SWANSEA
"Design of Hangars," by J. M. Burke. Wales and Monmouthshire Branch. Mackworth Hotel, Swansea. Wed., Jan. 16, 6.30 p.m.

Junior Institution of Engineers

LONDON
"History of Diving," by C. E. T. Warren. Fri., Jan. 18, 7 p.m.*
MANCHESTER
Chairman's Address by H. Smethurst. North Western Section. Engineers' Club, Albert-square, Manchester. Mon., Jan. 14, 7.30 p.m.
SHEFFIELD
"Some Interesting Safety Devices," by J. L. Faris. Sheffield Section. Livesey Clegg House, Union-street, Sheffield. Mon., Jan. 14, 7.30 p.m.

Reinforced Concrete Association

LONDON
"Reinforced Concrete in Architecture," by Edward D. Mills. 11 Upper Belgrave-street, S.W.1. Wed., Jan. 16, 6 p.m.*

Royal Aeronautical Society

LONDON
"Electronic Control Techniques in Aircraft Manufacture," by G. S. Kermack and H. Ogden. Thurs., Jan. 17, 7 p.m.

Royal Microscopical Society

LONDON
Annual General Meeting. Presidental Address on "Fluorescence Microscopy," by J. Smiles. Wed., Jan. 16, 5.30 p.m.

Royal Statistical Society

NEWCASTLE-UPON-TYNE
"Accidents and Road Layout," by J. C. Tanner. North Eastern Industrial Applications Group. King's College, Claremont-road, Newcastle-upon-Tyne. Tues., Jan. 15, 6.45 p.m.*

Sheffield Metallurgical Association

SHEFFIELD
Annual General Meeting of the Refractories Group and Chairman's Address by Dr. W. F. Ford. B.I.S.R.A. Laboratories, Hoyle-street, Sheffield, 3. Tues., Jan. 15, 7 p.m.

GENERATING PLANT INSTALLED IN 1956

New Record Achievement

New generating plant installed by the Central Electricity Authority during the year ended December 31, 1956, yielded an additional output capacity of 1,797 MW. Furthermore, new plant with an output capacity of 140 MW was commissioned in power stations owned by the South of Scotland Electricity Board, making a total of 1,937 MW of generating capacity provided in the area of the former British Electricity Authority. This surpasses last year's record total of 1,721 MW by 12½ per cent. and is a new high record. The additional C.E.A. plant, comprising 38 turbo-generators, with an aggregate installed capacity of 1,920 MW, and 50 boilers having an aggregate evaporative capacity of 18,715,000 lb./hr., was installed in 33 power stations. Four are new stations in which plant was installed for the first time.

In view of misunderstandings which appear to exist in certain quarters regarding the length of time required for the construction of conventional steam power stations—periods of seven or eight years often being quoted—the Authority point out that the initial construction following Ministerial consent is usually about 3½ years. The first unit in the twin Stella power stations on the Tyne was generating power 3½ years after consent, and eight more units—making 540 MW capacity in all—were installed within a further period of 24 months. At Ince power station in Cheshire the first unit was also generating electricity 3½ years after consent to proceed, and the station of 240 MW was completed by the installation of three more units within the next 21 months.

The full development of the Marchwood site on Southampton Water envisages the installation of eight 60 MW units, planned to be installed in two groups. The installation of the first four sets in this station has now been completed. The first set was commissioned 3¼ years from the commencement of site work, and the next three sets were commissioned within a further period of twelve months, thus increasing the plant available in the area by 240 MW. This result was achieved notwithstanding the complexities involved in carrying out the decision that oil should be burned in this station; for which change formal consent was given only nine months before the commissioning of the first set.

Power station	C.E.A. Division	Turbo-generator plant: Installed capacity in MW	Boiler plant: Capacity in 1,000 lb./hr.
Steam Plant:			
ACTON LANE "B"	London	—	1 × 240
BOLD "A"	N. West.	1 × 30	1 × 300
BRUNSWICK WHARF	London	1 × 60	1 × 320
CARMARTHEN BAY	S. Wales	1 × 60	2 × 240
CARRINGTON	N. West.	1 × 60	2 × 360
CASTLE DONINGTON	E. Mid.	1 × 100	2 × 830
CHADDERTON "B"	N. West.	1 × 60	1 × 360
CONNAHS QUAY	N. West.	1 × 30	1 × 300
DEPTFORD EAST H.P.	London	—	1 × 250
DONCASTER "B"	Yorks.	2 × 30	—
EAST YELLAND	S. West.	2 × 30	4 × 180
GOLDINGTON	East.	2 × 30	2 × 300
HAMS HALL "C"	Mid.	2 × 60	2 × 550
HUDDERSFIELD	Yorks.	—	1 × 180
HUNCOAT	N. West.	1 × 30	1 × 305
INCE	N. West.	1 × 60	1 × 550
LITTLEBROOK "C"	S. East.	1 × 60	—
MARCHWOOD	South.	3 × 60	3 × 550
MEAFORD "B"	Mid.	1 × 60	2 × 515
NORTHAMPTON H.P.	E. Mid.	1 × 30	2 × 150
NOTTINGHAM H.P.	E. Mid.	—	1 × 300
OCKER HILL "A"	Mid.	2 × 30	2 × 180
PORTISHEAD "B"	S. West.	1 × 60	3 × 300
SKELTON GRANGE "A"	Yorks.	—	1 × 550
STAYTHORPE "A"	E. Mid.	1 × 60	1 × 240
STELLA NORTH	N. East.	2 × 60	2 × 550
STELLA SOUTH	N. East.	2 × 60	2 × 550
TILBURY "A"	East.	3 × 60	3 × 540
USKMOUTH "A"	S. Wales	1 × 60	—
WAKEFIELD "B"	Yorks.	2 × 60	2 × 550
WOOLWICH	London	—	1 × 180
YORK	N.E., Yorks.	1 × 20	2 × 100
32 stations including 3 new stations	12 divisions including headquarters	38 turbo-generators having an aggregate installed capacity of 1,920 MW	50 boilers having an aggregate installed capacity of 18,715,000 lb./hr.
Diesel Plant:			
MACHYNLLETH "B"	N. West.	3 × 1·33	—
1 new station	1 division	3 Diesel sets having an aggregate installed capacity of 3·99 MW	—

Note.—The power stations whose names are in large capitals are new stations, in which plant has been commissioned for the first time in 1956. The others are existing stations to which extensions have been made.

CURRENTS BETWEEN SCYLLA AND CHARYBDIS

The problem of unemployment in the over-populated South of Italy is closely bound up with the lack of power. Sicily has no coal and very little hydro-electric power. Even with the development of Sicilian oil reserves it is still necessary to look to the mainland for the vital electric power. The problem of getting electric power cables across the treacherous waters of the Straits of Messina, between the famous rocks of Scylla and Charybdis had first to be solved. Three possible solutions were studied. The idea of an underground tunnel had to be dropped as the bed of the Straits is too sandy for tunnelling. Deep-sea cables could not be used because of fast sea currents. This left overhead cables as the only possible solution. The major difficulties were to find a suitable bed on which to build the pylons, 728 ft. in height, able to stand the pressure of high winds and the strains imposed by earth tremors.

There are to be two pylons at each end set to give a distance of 27 yards between cables at mid-span. The cables, which are 5,850 yards long, were made all in one piece without any joins. They are protected from corrosion by a thick zinc plating. The most difficult task was to erect the cables without letting them touch the surface of the water. The base of each pylon is anchored to a cross-shaped concrete structure. An arrangement of hydraulic jacks is provided which can be used to enable wedges to be placed under the feet of the pylons should these be put out of the horizontal by earthquake shocks. The overhead cables have now completed their first year of service to everyone's satisfaction. The provision of cheap electric power is already proving of immense value in the fight of the semi-autonomous Sicilian Government to provide jobs for its numerous unemployed.

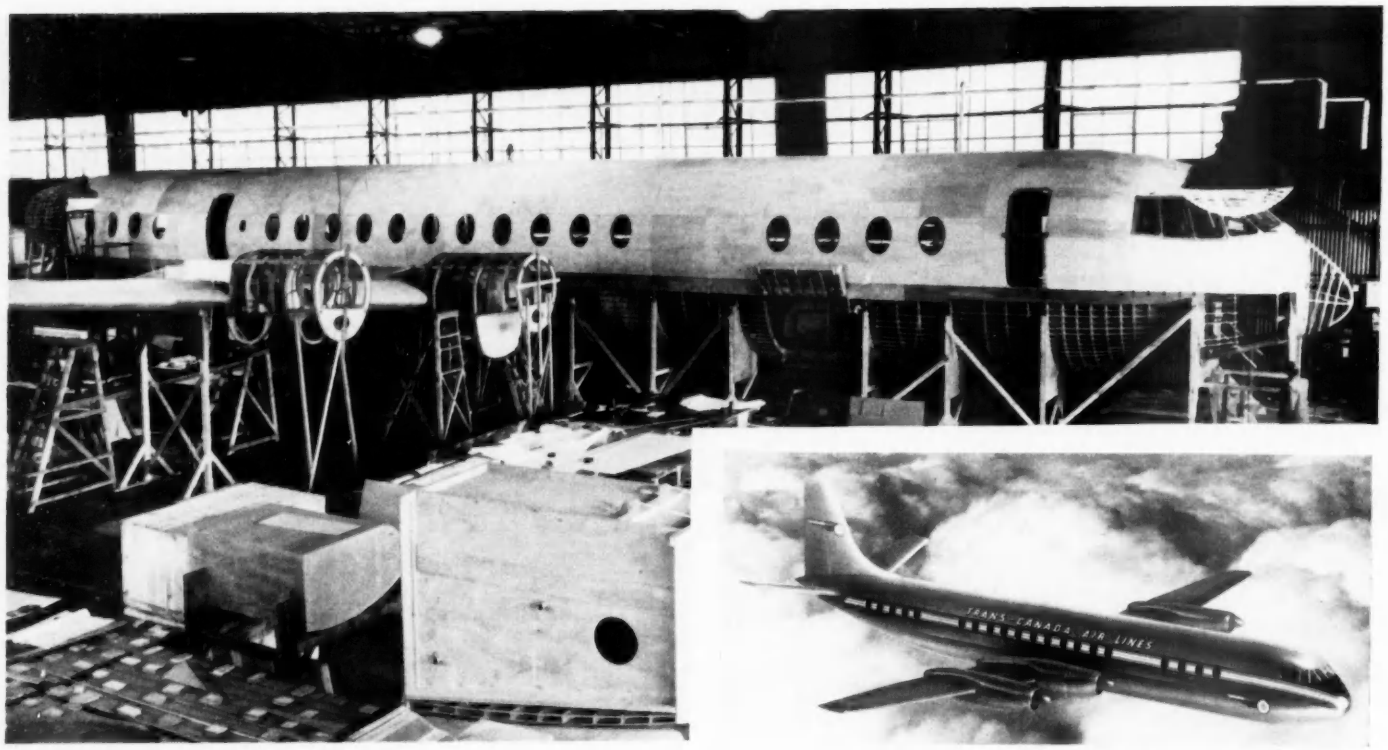


Fig. 1 The full-scale Vanguard mock-up at the Vickers-Armstrongs factory at Weybridge.

Fig. 2 An artist's impression of a T.C.A. Vickers Vanguard propeller turbine airliner.

T.C.A. VANGUARD AIRLINERS

DRAWING BOARD ORDERS

Vickers-Armstrongs (Aircraft) Limited, Weybridge, Surrey, have started their new year well with an order for 20 Vanguard propeller-turbine airliners placed by Trans-Canada Air Lines. This happy event is a measure of the success that Trans-Canada have had with their operations with the Dart-powered Viscounts, of which they have already ordered 38. The Vanguard also is to be powered by Rolls-Royce propeller turbines—the Tyne, the Mark 2 version of which will develop 5,315 e.h.p. It is of particular significance that Trans-Canada have selected propeller-turbine machines as being more economical and versatile, and presenting no airfield and traffic control problems, in preference to short-range turbojet airliners that they have been assessing side by side with the Vanguards. They have also preferred the Vanguard to a Tyne-powered version of the Lockheed Electra aircraft—a natural reaction in view of the fact that they already have Viscount aircraft operating satisfactorily, and are learning to know the family characteristics of the Vickers-Armstrongs breed.

On the question of turbojet versus propeller turbine for the medium-range airliner, Mr. George Edwards—awarded a knighthood in the New Year Honours List—has stated that Vickers-Armstrongs, who have operating experience both of propeller-turbine aircraft and the jet-powered Valiant bombers, have themselves made some evaluation of the possibilities of a turbojet-powered medium-range airliner, and have concluded that it would be completely outclassed economically by the propeller-turbine machine.

The Vanguard is not due to fly until 1958, but construction of the first aircraft has commenced, and a full-scale wooden mock-up, shown in Fig. 1, is already in existence. An artist's impression of Trans-Canada's future Vanguards is given in Fig. 2.

One of the aspects of all the aircraft examined by T.C.A. before choosing the Vanguard, and to which particular attention was paid, was the detailed engineering for ease of maintenance, high utilisation, accessibility and quick turn-round.

In order to meet T.C.A.'s particular requirements for a full passenger payload and a high proportion of mail space, the Vanguard has been given a higher all-up weight than previously announced, and now has a 24,000 lb. payload. The structure has also been modified to enable the aircraft to use its full cruising power at lower altitude in cognisance of the air-traffic control problems which arise particularly in winter on the east coast of North America.

As with the Viscount, the Vanguard will be delivered to T.C.A. in an "Americanised" version and fully "winterised." Equipment and electrical systems will all conform to North American requirements. It will be recalled that it was in co-operation with T.C.A. that the Viscount was developed for North American operation—a co-operation which paved the way for the success that aircraft is now enjoying both in Canada and the United States.

It will have an all-up weight of 141,000 lb., a maximum landing weight of 114,000 lb., a payload of 24,000 lb., and a fuel capacity of 5,100 Imperial gallons. With four Rolls-Royce Tyne engines of 5,315 e.h.p., the cruising speed will be over 420 m.p.h. The effective stage range in the worst Canadian winter conditions will be 1,750 miles; and, with a payload of 21,500 lb., the still air range is 3,000 miles and the stage range with reserves is 2,600 miles. The aircraft will normally cruise at 20,000 ft., but is pressurised to give an equivalent cabin altitude of 8,000 ft. when the aircraft is flying at 30,000 ft.

The T.C.A. Vanguard will carry 82 first class or 102 tourist passengers and a mixed-class version of 60 per cent. tourist and 40 per cent. first class is also possible. The interior layout will include four washrooms and two galleys.

The Vickers Vanguard, it may be recalled, is of "double bubble" fuselage construction. The top portion of this "double bubble" is for passenger accommodation and the lower part is for freight. There are two very large cargo holds with a total capacity of 1,410 cub. ft. The freight space is entirely separate from the passenger accommodation and the T.C.A. aircraft is designed to carry nearly its full payload in the freight compartments without disturbance to the passenger seating. The aircraft has thus been designed for year-round day and night operation to give flexibility of role as well as of operation. The dimensions are: wing span, 118 ft.; overall length, 122 ft. 4 in.; overall height, 34 ft. 11 in.; and cabin interior width (maximum), 10 ft. 9 in.

By 1961, Trans-Canada expect to be completely turbine-powered—and all their fleets will have Rolls-Royce power units: their DC8 trans-atlantic and transcontinental air liners with Conway by-pass turbojets; Vanguards, on the high-density domestic and southern-service routes, with Tyne propeller turbines; and Viscounts on the shorter stage lengths with Dart propeller turbines.

The order, which has been valued at over 67 million dollars, is more than a commercial and technical triumph. It is a triumph of an attitude of mind. The Vanguard has been built by Vickers as a private venture and this large order, claimed to be the largest commercial dollar export order placed in this country since the war, has been ordered from drawing-board data.

The successful gaining of the order emphasises two points. First, the Vanguard represents a major tactical success in the British attack on the medium-range civil aircraft market. Second, it vindicates the decision of several British manufacturers who put their resources into the turbo-prop aircraft as opposed to the jet. On the first of these it has to be remembered that the Americans are making great strides with the design of two jet aircraft on the long distance routes and that this country cannot now challenge this lead before the 1960's. It may be that in another 5 or 10 years this country may be able to offer a jet machine which will be an important export line. Meanwhile the medium-range turbo-prop is becoming established as a vital export earner. On the second point it can be said that British manufacturers backed their judgment with finance and energy. They have produced something new, that is good and that sells. They are following up with even better ideas based on recent successes.

Marketing

OPPORTUNITY KNOCKS

" The Commonwealth and South East Asia have need of the British genius for pioneer initiative and inborn inventiveness to advance developments on a scale that would otherwise be impossible." This was the cheerful and confident view of Mr. Lawrence W. Robson on his return from a 34,000 mile overseas tour which took him to North America, Japan, Hong Kong, the Philippines, Australia, New Zealand, Singapore, Ceylon and India. Mr. Robson is chairman of Associated British Engineering Limited and of several other engineering companies. He went to see how far his companies' interests could be promoted by overseas enterprise and returned " heartened and emboldened to pursue plans for the development of A.B.E. interests on a scale far beyond that which I would have contemplated before my tour."

Mr. Robson considers that the long-standing trade relationship built up on the exchange of British manufactures for Commonwealth raw materials is rapidly becoming outmoded. Politically those countries are bent on a policy of setting up primary and secondary industries and their greatest needs are for industrial experience, engineering skills and capital. British industry must be prepared to provide these, " to seize the chance now offered to come in on the ground floor of a 50 year programme."

The argument is simply put: invest and trade will follow, particularly in engineering. Our United States and German competitors and their Governments understand this only too well. But these two countries have a surplus of income over expenditure. The need for British enterprise, and the great opportunities open to it, are undeniable. The problem is how to save enough and how to train enough engineers to supply the needs of the Commonwealth.

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Sales News From Companies

The growth of business in the oil fields has led Ruston and Hornsby Limited to set up a special department within their Export Sales organisation to deal with it. Much of the expansion has been in the company's range of Diesel engines and gas-turbines of medium size—an average 1,300 b.h.p. output—for which the potential is said to be increasing. The new department will be led by Mr. Brian S. Page who will co-ordinate all enquiries and contract technicalities, dealing direct with the oil companies. The kind of attentive, personal service the move is likely to produce is an essential prerequisite of successful dealing with the oil companies.

Another new sales department has been created by Ruston and Hornsby for the sale of engines from 4 to 150 b.h.p. This Small Engine Sales Department, under the management of Mr. John Needham, will deal exclusively with the marketing of engines in the company's YB, YC and YE ranges in the United Kingdom and the Irish Republic. New production lines have been laid down in recent years and Rustons hope greatly to expand small-engine sales, particularly to driven-machinery manufacturers.

An announcement by the Simon Engineering Group is believed to break fresh ground in overseas representation of British companies. Simon-Carves Limited have appointed Mr. H. S. Malik, lately Indian Ambassador to France, to be their special director in India to take charge of their important interests there. Mr. Malik, an Oxford graduate and a member of the Indian Civil Service, has had a distinguished political and diplomatic career which has included very senior Government appointments both at home and overseas—most of them in industrial or commercial fields. This is an interesting example of the trend towards partnership between British firms and nationals of their overseas markets. Already common practice in investment projects, it may become widespread in the fields of production and sales. Appointments of this kind augur well for a close and fruitful co-operation of British and Commonwealth interests.

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Glossy Public Relations

The latest brochure issued by the British Petroleum Company, Limited, *News in Pictures*, 1956, is a very good example of the modern tendency to convey information to customers and the public at large by photographs on fine glossy paper. In this case a wide range of B.P.'s activities is illustrated by excellent photographs which provide a great deal of local colour and as much personality interest as possible.

The composition of the brochure is clever, and has obviously been carefully thought out. It opens with photographs of the drums containing the petroleum products which " B.P. is providing at its own expense " for the Trans-antarctic Expedition; pictures of Dr. Fuchs, the Theron, Sir Edmund Hilary driving a tractor " helping to unload aviation fuel," complete the story. Next comes road tests in London by a team from B.P.'s Sunbury research station " to study the performance of motor fuels under various conditions in different parts of the world." Oilfields—their operation, exploration and the facilities there; motor racing ; colourful personalities—Mr. B. R. Jackson, chairman of B.P., the Sultan of Zanzibar, Stirling Moss and others, combine to give an intimate and most complete introduction to all with an interest in B.P. Even a quick flick through conveys a great deal—the brief captions tell a stimulating story, world-wide in its compass and full of interest.

Inside the brochure is slipped a newsletter which relates in short paragraphs B.P.'s major development in 1956. The emphasis is on service, to the nation and to those who have dealings with B.P., on research, education, progress (in various forms, including technical) and on personalities. This conception of public relations is catching on in British industry. The B.P. brochure will repay careful study.

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Publicity With Meaning

Firms which set out to provide their customers' staff with technical information and reference data often succeed in " winning friends and influencing people," hence the popularity of this method of publicity. Few, however, go to the lengths of publishing a 700 page manual as do A.E.G., the giants of German electrical engineering. The latest (seventh) edition of the *A.E.G. Hilfsbuch für Elektrische Wicht und Kraft* contains a detailed account of the company's activities and products. It is, in effect, a very good handbook of heavy electrical engineering, profusely illustrated with photographs, drawings and statistical tables.

The opening chapter deals with symbols, units and standards, with briefly illustrated descriptions of typical machines, equipment and material. It is followed by some 40 pages on prime movers and heavy rotating machines. There are shorter sections on transformers, rectifiers and converters and a much larger one on switchgear of various types. Measuring apparatus, including clocks, is next dealt with, followed by cables and cable accessories, insulating materials and motors. There are useful closing chapters on electrical heating in industry, electric traction, power-factor improvement and lighting.

So large a book could be better indexed, and would be improved by a good bibliography. It is nevertheless likely to be found most useful, even by those electrical engineers who have no intention of specifying or buying German equipment when the English translation does become available. The A.E.G. handbook is good educative publicity, and the company's example could be followed with advantage by British concerns, especially for distribution to overseas customers.

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Leipzig Spring Fair

Great efforts are being made to establish the Leipzig Fair as the great meeting ground of East and West. In March, some 10,000 exhibitors from 40 countries will occupy nearly 3 million square feet of exhibition grounds and halls. East Germany will take up half the total space and West Germany over 320,000 sq. ft. An announcement last week by the Leipzig Fair Agency, 127 Oxford-street, W.1, indicates that formalities have been reduced to a minimum, air services improved and a bonus of 100 per cent. on the official currency exchange rate offered to British travellers.

The technical fair, to be held from March 3 to 14, incorporates interesting new features. Aircraft will be on show for the first time, and several German firms are exhibiting complete industrial installations. Machine tools will be the foundation of the display, which will include machinery and plant of all kinds with particular emphasis on electronic engineering, chemical and civil engineering plant.

The recent trade agreement between the British and Polish Governments and the continuing trend of increased trade between East and West (due, in no small measure, to the movement among eastern European countries towards political and economic independence from Russia) suggest that British exhibitors may reap a reward for their enterprise next March.

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Business's Economic Forecasters

A picture of the business economist as " a lookout, to survey the horizon for objects or signs of interest to . . . industry " was sketched in an article published in the December/January issue of the Du Pont magazine. The author, Mr. Ira T. Ellis, is Du Pont's chief economist and his interpretation of the functions of his department is both interesting and authoritative. The business economist, according to Mr. Ellis, " is still a relatively new phenomenon and, as such excites the curiosity of his more traditional colleagues." Yet in this country at least two groups of these curiosities meet frequently to discuss their problems and exchange notes on the burning questions of the day. Typical of these: how rapidly is personal income rising? Is business activity rising or falling? Are stocks high or low? What is happening to taxes, interest rates, prices? It is the job of the business economist to study these problems, to explain, forecast and point out the meaning of changes for specific industries and for his own company.

In addition, Mr. Ellis points out, he is there to advise his company on how they should finance operations, where their new plants should be located, on the choice of sales channels and outlets and on price levels. The U.K. " Business Economics Group," which meet at P.E.P. under the chairmanship of Mr. Campbell Fraser of the Economist Intelligence Unit, include among their members economists from Esso, Ford, I.C.I., United Steel and many other leading companies. They, like their American colleagues, have no reliable crystal ball or confidential sources of information. There is no alternative, to a meticulous study of production statistics, stocks, prices, wages, employment, income, spending, saving and all other aspects of the economy to point to what the future may hold.

THE HUMAN ELEMENT

Children and the romance of science—All talk and no do—Unfortunate timing on price inflation—Another claim from the miners?—A dangerous illusion about full employment—Penalties for self-help in the welfare state.

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Specialist Training

The shortage of specialist teachers in secondary schools is likely to become critical during the next few years as the large age groups—the post-war bulge—reach that stage of their education. Sir David Eccles, Minister of Education, who had earlier announced a scheme for a more effective distribution of available teachers and for a substantial increase in the numbers taken by training colleges (The Human Element, December 21), has appealed to local authorities to release teachers for specialist training. The most urgent need, he said, was for more teachers of such subjects as science, mathematics, housecraft, needlework, handicraft (woodwork and metalwork) and physical education. Courses in these subjects are being offered to serving teachers and to training college students on completion of their initial training. In his memorandum to the local authorities the Minister said: "The next few years will be particularly critical for the secondary schools and it is of the utmost importance that as many teachers as possible should attend the courses."

This is a belated realisation that the majority of teachers in secondary schools know not even the a, b, c of scientific and practical subjects. Most have forgotten the elementary mathematics and science they learnt at school or remember them only in the abstract. They are therefore in no position to introduce the scientific subjects, in their everyday teaching, in a manner that will excite the curiosity of the child. A permanent solution is not Sir David Eccles' supplementary or specialist courses, but a broadening of the education of all teachers to include science and technology as well as the humanities. This was put forward by Sir Alexander Todd of Cambridge University, in his presidential address to the annual meeting of the Science Masters' Association. Sir Alexander advocated a broadening of the school curriculum and the introduction of something like a "Science Greats" degree to produce science teachers with a broad outlook. Children, he said, should at an early age be made aware of "the romance of science and the vast sweep of its applications."

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T.U.C. on Automation

A pamphlet put out by the Trades Union Congress called "Automation and the Trade Unions" should be widely read by office and factory workers. It is a useful antidote to the scare headlines in as much as it points out that automation has been going on in an undramatic way for a decade or two. A good deal of the information comes from the report on the subject by the Department of Scientific and Industrial Research. The pamphlet is, however, none the worse for that.

In the eyes of the T.U.C. the important considerations from the workers' point of view are the need to insist on having full information and discussion well in advance of automation being introduced. Every effort must be made, it goes on, to provide displaced workers with alternative jobs and to consider ways and means of effecting the transfer, including compensation payments. Retraining facilities are important and there is the expected proviso about wage rates and working conditions.

All this is eminently reasonable. Organised labour, however, could easily fall into the same danger as may yet beset management on this subject. Everyone in responsible positions is being broad-minded and sweetly reasonable on automation. On matters affecting the actual introduction of it as opposed to merely talking about its impact when it comes, there is still a lot of hard thinking and talking to be done. There are a number of matters affecting automation, such as redundancy and compensation, which would be the better for an airing at the top of the labour-management structure. Yet so far little has been done about it. Everyone is busy saying that action must be taken in advance to create the best possible industrial atmosphere and there is little energy left over for getting on with it.

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Higher Prices Forecast

The Treasury estimate that the rise in the petrol and oil duty, higher distribution costs and other increases due to the Suez crisis will send up the retail price index by three-quarters of one point. Coming at a time of wage claims, some of which have already been rejected on the grounds that there is no justification for granting them, such a rise is most untimely. It threatens to wreck the Government's stable price policy and to give inflation just the gentle push it needed to rush ahead once more. It would seem therefore that the decision to raise the duty on petrol and oil—which will alone add one-quarter of a point to the index—was bad psychology. The same could be said of the withdrawal of the bread subsidy and, this month, of that on milk. Whatever the economic justification for these moves—it can only be doubtful in the case of petrol and oil, where rationing has been introduced to keep down consumption—they could not have been more unfortunately timed.

The Treasury emphasise that the rise in the index is temporary and therefore no justification "for increases in wages and profit margins, which in themselves would tend permanently to raise the price level." The Unions are well aware of the risk they will be taking if they force employers to grant wage increases at a time when export demand for most manufactured goods is becoming increasingly price conscious. Yet they may find it difficult to resist pressure from rank and file faced with higher prices for bread and milk, higher health service charges and higher fares, The fact that all together do not add up to one point of the cost of living index has unfortunately little bearing on the psychology of inflation.

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Opposition on Miners' Bonus

The agreement between the National Coal Board and the National Union of Mineworkers to postpone a decision on the bonus shift problem has run into stormy waters. Several of the large areas have voted against it and it may well be that there will have to be a national conference of the N.U.M. to decide the next step. The union thought that it could avoid putting the N.C.B. in a difficult position while the Suez crisis lasted by trying to force through the abolition of the sixth shift arrangement. There are now signs that the position is not fully appreciated at area level among the miners.

It may be that the executive will retrieve the position when it tells miners' delegates that the N.C.B. has not turned down the proposal for reasons of finance, but only wished to be able to take a final decision against a more stable economic background than exists at present. There is also the N.C.B. offer to increase pensions under the industry's pensions scheme to be passed on to the delegates.

The real danger is, of course, that the miners will start seeking a wage increase. There is already considerable pressure at area level for such a move and many local organisations are somewhat impatient about the national executive's preference to use 1957 as a year for tidying up a series of points under the "miners' charter" which was a fashionable item of discussion two years ago in mining circles. There is nothing quite as bad, however, as former years' trade union conferences once the opinion becomes current that a wage demand is due.

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Workers Rights and Obligations

Sir Frederic Hooper, the managing director of Schweppes Limited, wrote in a recent article that reasonable working conditions must be conceded as a right not as a privilege. A new, highly-paid class had arisen which was bent on enjoying its new position based on high wages, and which was highly organised and able to extract what it thought it could get.

The problem, however, may be less based on a question of right versus privilege than of right versus might. It is certainly true, as Sir Frederic says, that good conditions can no longer be handed out as a sop in return for a day's work. To let organised labour assume that it has a right to them may be as dangerous, however, as to let workers think that they have a right to a particular job in a particular company. If people have rights they also have obligations. No civilised society can be run on any other basis. The trouble is that rights are usually conceded in return for future fulfilment of obligations and it is not always possible to extract these at a later date. On the other hand, organised labour is certainly in a position to extract certain conditions and it can reasonably make the basic claim that a man has a right to work in a society that functions by a complicated division of labour.

Organised labour may think, however, that what arises from a strong economic position (namely, full employment) has become vested in moral garb. It is a common confusion to think that what one can get is no more than what one is entitled to. It is indeed a significant comment on full employment that what arises from a fortunate (and no doubt well-earned) combination of economic circumstances has achieved moral status. If it is true, full employment has ceased to be a goal and is now taken for granted. This could be a dangerous illusion.

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Of Homes and Castles

Every man's home is his castle, so goes the old saying. In the planners' paradise of to-morrow where most of us live in rented accommodation largely at the ratepayers' expense, work like ants for the common good and retire on £2 a week, such things are going to be changed. We shall presumably own nothing but enjoy everything.

Some of the more intricate aspects of such a form of existence come to light from time to time in the individual's dealings with government departments, central or local. A recent example of this comes from Not inghamshire. In that county a certain rural district council redecorated some council houses and the colour scheme, it is claimed, made the wife of one of the tenants ill to look at it. She had been suffering from nerves. There then followed the submission of medical certificates to support the request of the tenant to redecorate the house at his own expense. The council has now said that he can repaint the house himself if he does the one next door as well. The discussion still goes on.

In this nightmare of petty bureaucratic procedure and form-filling it is always the enterprising who suffer. The tenant's family could have done a vast amount of minor damage to the council's property before they earned eviction, but the thought that a few pots of paint might be used on the walls quickly brings into operation a tedious procedure in which officials are mainly concerned with the setting of precedents. As long as people live in houses at heavily subsidised rents they may expect to put up with this sort of thing, but it is a poor alternative to a man living in his own house or in accommodation rented from an ordinary landlord.